doc Asp 2

2. Room 522

The ventilation or hood ducts located in this room and extending down to the fourth floor have levels of radioactivity which cannot be easily quantitated or decontaminated. We recommend, therefore, that these ducts be permanently sealed.

3. Roof area near the skylight over Room 507

There is contaminated gravel on the roof around the skylight. The individual pieces of gravel probably have considerably less than would be found on a radium dial wrist watch, however due to the type of material involved and the large equipment and trash on the roof, it is a virtually impossible problem to evaluate. We recommend, therefore, that the large equipment be disposed of. Also, fresh tar and at least an inch of fresh gravel should be poured on the roof covering the area from the skylight out to the edge of the roof on all sides, but it is not necessary to exceed a distance of 10 feet from the skylight.

4. Room 504

This room had shelves and old pieces of equipment left in the area by NBS. Because of the presence of low levels of contamination covering wide areas of the floor, we would like to evaluate this area further after the equipment and shelves have been removed.

In conclusion, although there does remain small amounts of activity in a few isolated areas, the levels are within safe limits. We have used as guidelines the recommendations of the U.S. Public Health Service as indicated on Attachment 3. Also enclosed is a copy of an article by H.F. Klein and G.D. Schmidt which provides information on contamination limits used by other agencies. The guidelines of the U.S. Public Health Service, and the ones used in our evaluation were lower than those used by most other agencies. We feel, therefore, that no radiation hazard exists in any of the buildings evaluated. (See list below.) Furthermore, subject to the recommendations discussed above, we believe that no radiation hazards from this contamination will recur in the future.

Buildings surveyed:

Building #2
" #3
" #4
" #7
" #78
" #45
" #129
" #2100
Tunnel between Bldg. #2 and #4

HSL/op

doc A9

[illegible]
[illegible]
WASHINGTON, D.C. [illegible]

February 14, 1968

Mr. Robert S. Walleigh
Associate Director for Administration
National Bureau of Standards
Gaithersburg, Maryland

Dear Mr. Walleigh:

On February 5, 1968, the District of Columbia took possession of six buildings (#2, 3, 4, 5, 7, & 12) from the General Services Administration. It is our understanding that these particular buildings were previously occupied by the National Bureau of Standards and that considerable work with radioactive materials took place in certain areas of specific buildings.

This office was recently requested by the District's Department of Buildings and Grounds to investigate and report on those areas still posted with radioactive material warning signs. A preliminary investigation of the first building scheduled for occupancy (Bldg. #2) disclosed that one room (#518) on the fifth floor was sealed with warning tape used to identify areas containing radioactive material. Monitoring of this room and three adjacent rooms (#519, 520 & 521) disclosed significant alpha contamination. In room #507 significant beta - gamma contamination was found on the floor and significant alpha contamination was identified on one rafter.

Our findings during this survey indicate the need for comprehensive monitoring of all areas in which radioactive material was stored, used, or handled. In order that we may expedite our survey and report it is requested that your office provide us with the following information:

1. Specific rooms or work areas where radioactive material was used, stored, or produced.

2. Copies of any final monitoring surveys conducted for these areas.

3. Information as to action taken, if any, to insure that radioactivity levels were reduced to nationally acceptable

levels prior to the vacating of the premises by the Bureau of Standards.

Your early attention to this request for information would be appreciated.

Sincerely yours,

John V. Brink, Chief
Bureau of Public Health Engineering

Copy to Philip Smith
copy Marshall Little
Radiological Safety
Copy Walleigh
Copy for Meinke
file
Olenda

INBOX: ginnybond

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To:

Subject: Re: hello!

Date: Mon, 18 Apr 2005 07:11:01 +0000

Hi I didn't get to read my email until this unseemly hour of the morning, but I shall try to check on it tomorrow. I assume that the email from refers to the levels of radiation in a report in one of the packets that you sent. And I do recall that when I read about the radiation in Building 2, the levels that were reported just about scared me to death. I am amazed that I am still here at 84 years of age after all that exposure and after the subsequent exposure that I got working with neutron sources. In any case, just reproducing that report in your SEC petition seems quite adequate to me. As I recall, the building was abandonned and was later torn down to make another structure, but we can check on that.
Good luck,

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comcast

Doc A 10

EEOICPA BULLETIN NO.03-11

doc A 11

Issue Date: November 19, 2002

Effective Date: November 19, 2002

Expiration Date: November 19, 2003

Subject: Additional Cancers Considered as Primary Cancers

Background: 20 CFR 30.5 (dd)(6) states that specified cancers are "the physiological condition or conditions that are recognized by the National Cancer Institute under those names or nomenclature, or under any previously accepted or commonly used names or nomenclature." The Department of Labor (DOL) forwarded a list of six medical conditions to the National Cancer Institute (NCI) for their review and classification to determine which conditions could be considered as cancers under the EEOICPA. The six medical conditions sent to NCI were:

myelofibrosis with myeloid metaplasia;

polycythemia vera with leukocytosis and thrombocytosis;

polycythemia rubra vera;

myelodysplastic syndromes;

carcinoid tumors or carcinoid syndrome; and

monoclonal gammopathies of undetermined significance.

On October 8, 2002, DOL received a letter from Dr. E. G. Fiegal, the Acting Director of NCI's Division of Treatment and Diagnosis, detailing NCI's evaluation of the above mentioned six medical conditions.

According to Dr. Fiegel, NCI recognizes myelofibrosis with myeloid metaplasia, polycythemia vera with leukocytosis and thrombocytosis, polycythemia rubra vera, and myelodysplastic syndromes as reportable cancers. These hematological conditions are not reportable as leukemia, non-Hodgkin's lymphoma, or multiple myeloma, but have distinct categories (except in the case of polycythemia rubra vera and polycythemia vera with leukocytosis and thrombocytosis, which share the same category). One of the functions of bone is to manufacture blood cells in the bone marrow. Accordingly, myelofibrosis with myeloid metaplasia, polycythemia rubra vera and its variant polycythemia vera with leukocytosis and thrombocytosis, and myelodysplastic syndrome(s) should be considered as bone cancer for purposes of having a "specified cancer" as a member of the Special Exposure Cohort, since all are malignancies of the bone marrow.

Carcinoid syndrome and monoclonal gammopathies of undetermined significance are not currently recognized as malignant conditions by NCI. Consequently, these conditions doc A11 p2.

should not be considered as cancers.

Carcinoid tumors, except of the appendix, are recognized as malignant conditions by NCI and should be considered to be primary cancers of the organs in which they are located. If the organ is one on the specified cancer list, the carcinoid tumor may be considered as a specified cancer. Carcinoid tumors are found in greatest amounts in the small intestine and then in decreasing frequency in the appendix, rectum, lung, pancreas and very rarely in the ovaries, testes, liver, bile ducts and other locations.

Reference: Energy Employees Occupational Illness Compensation Program Act of 2000, As Amended, 42 U.S.C. § 7384 *et seq.*, Section 73841(17); interim final rule 20 CFR Part 30, Section 30.5 (dd); and a letter from Dr. E. G. Fiegal, NCI, to R. Leiton, DOL, dated October 8, 2002.

Purpose: To notify District Offices of the classification of six additional medical conditions as primary cancers for eligible SEC claimants under the EEOICPA.

Applicability: All staff.

Actions:

The CE should consider: (1) myelofibrosis with myeloid metaplasia; (2) polycythemia rubra vera; (3) polycythemia vera with leukocytosis and thrombocytosis; and (4) myelodysplastic syndrome(s) to be bone cancer, which is a specified primary cancer per EEOICPA Section 73841(17)(B).

2. Carcinoid tumors, except of the appendix, are recognized as malignant conditions by NCI. If the organ is one on the specified cancer list, the CE should consider the carcinoid tumor as a specified cancer (per EEOICPA Section 73841(17)).

3. Carcinoid syndrome and monoclonal gammopathies of undetermined significance are not currently recognized as malignant conditions by NCI. Consequently, these conditions should not be considered cancers by the CE. If no other medical conditions are claimed that qualify the employee as having a covered condition, the claim should be denied.

The CE must look for any other cases of the medical conditions discussed above that could make the claimant eligible for benefits, either as a member of the SEC or through dose reconstruction. A preliminary review of the ECMS is underway to determine which cases may have already been denied or sent to NIOSH. That list will be forwarded to each District Office under separate cover. Using that list, the District Office must pull any cases for review in accordance with this bulletin. If modification orders are required, the District Office should send the case to the National Office.

The CE must continue to distinguish these medical conditions from bone or other specified cancers, as appropriate, using the appropriate ICD-9 codes on all paperwork and in ECMS.

For the conditions to be considered as bone cancers, the ICD-9 code for a myeloid metaplasia is 289.8, polycythemia rubra vera and its variant polycythemia vera with leukocytosis and thrombocytosis is 238.4, and myelodysplastic syndrome is 238.7. The ICD-9 code for malignant neoplasm of the bone is 170.

Carcinoid tumors, except of the appendix, should be recorded by the organ of the specified cancer. For example, the CE should use the ICD-9 code of 170 for a carcinoid tumor in the small intestine.

Disposition: Retain until incorporated in the Federal (EEOICPA) Procedure Manual

PETER M. TURCIC

Director, Division of Energy Employees

Occupational Illness Compensation

Distribution List No. 1: Claims Examiners, Supervisory Claims Examiners, Technical Assistants, Customer Service Representatives, Fiscal Officers, FAB District Managers, Operation Chiefs, Hearing Representatives, District Office Mail & File Sections

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

doc A12

National Institute for Occupational Safety and Health
Robert A. Taft Laboratories
4676 Columbia Parkway, MS C-45
Cincinnati, OH 45226-1998
Phone: 513-533-8423
Fax: 513-533-6840

Case Status Report March 15, 2005

Individual Claim Status

Energy Employee:
NIOSH Tracking Number:

Cancers Verified by Department of Labor (DOL):

Cancer Description	Diagnosis Date
Myelofibrosis with myeloid metaplasia	

Employment and Exposure Information:

Employer(s) Verified by DOL	Employer Accepts Request for Exposure Monitoring Information	Date Request for Exposure Monitoring Information Sent	Date Exposure Monitoring Response Received
National Bureau of Standards, Van Ness Street	No	Not Applicable	Not Applicable

-Continued on Next Page

doc A 12 p. 2

Individual Claim Status(continued)

Claim Received from DOL:	*12/19/2002*
Acknowledgement Letter Sent to Claimant:	
Telephone Interview Conducted with Claimant:	12/08/2004
Report from Interview Sent to Claimant:	12/09/2004
Conflict of Interest Letter Sent to Claimant:	Not Completed
Dose Reconstruction Started:	Not Completed
Draft Dose Reconstruction Sent to Claimant:	Not Completed
Close Out Interview Conducted with Claimant:	Not Completed
OCAS-1 Returned to NIOSH:	Not Completed
Final Dose Reconstruction Sent to DOL:	Not Completed

doc A 13

U. S. Department of Commerce — National Bureau of Standards

RESEARCH PAPER RP1169

Part of Journal of Research of the National Bureau of Standards, Volume 22, January 1939

AN IMPROVED RADIO METEOROGRAPH ON THE OLLAND PRINCIPLE

By L. F. Curtiss, A. V. Astin, L. L. Stockmann, and B. W. Brown

ABSTRACT

A description is given of the construction and tests of a radio telemeter of high precision built according to the Olland principle, in which all indicating arms rotate on a common axis. Combined with a 5-meter radio transmitter of push-pull type, this telemeter provides a radio meteorograph which has been tested under actual working conditions and found to be reliable and accurate in its indications. Since it gives relatively strong signals with a good stability in frequency, it is easy to operate and very little retuning during an observation is required. Special attention has been given to the thermal insulation of the compartment containing batteries and transmitter so that no failures due to drop in battery temperature have been observed even at altitudes above 60,000 feet. The cost of manufacture compares very favorably with that of other models recently developed in this country.

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II. Radio telemeter	98

I. INTRODUCTION

In September 1935 the authors described [1] the results of their preliminary investigation into the possibilities of developing a practical system for observation of temperature, pressure, and relative humidity at high altitudes by means of radio-equipped sounding balloons. As there reported, the radio problems involved are very simple, and by using the Olland principle, which requires the transmitter to be in operation for a very small fraction of the observation period, relatively strong signals of 5-meters wave length can be obtained at all attainable altitudes and for distances of a hundred miles or more.

Attention has since been turned to the development of a radio telemeter which would be accurate in its indications and convenient to attach to a sounding balloon. In this period many models have been tested both in the laboratory and in the air. The chief problems encountered were those of: (1) Reliable keying contacts; (2) consistent indicating system for the sensitive elements; (3) adequate ventilation for the sensitive elements; (4) stable antenna position during flight; (5) maintenance of battery temperatures; and (6) dependable and uniform operation of the driving mechanism. The model here described has shown in repeated tests that these problems have been solved to the extent that they no longer interfere with reliable and accurate operation of the instrument.

[1] L. F. Curtiss and A. V. Astin, J. Aeron. Sci. 3, 35 (1935).

II. RADIO TELEMETER

The preliminary experiments were made with clock-driven equipment. These trials served a very useful purpose in testing the range and stability of the radio signals, but it soon became evident that escapement errors introduced by the clock movement seriously limited the accuracy. Furthermore, even slight decreases in temperature frequently caused the clockwork to stop, especially if the pressure on the contact arms carried by the motor was sufficient always to give dependable signals. Tests were therefore made of small direct-current motors,[2] which convinced us that they would provide a more satisfactory driving mechanism. Slow changes in speed could be corrected for automatically[3] in reading the record. Through cooperation of manufacturers small electric motors were made available. These weighed less than 50 grams and required about 5 milliamperes at 1.5 volts for their operation. Tests of their speed fluctuations revealed that the slow variations present could be kept to less than a few percent. In addition, these motors rarely stop in flight since they operate without lubricants and have about 100 times the power of a spring-driven clock of the same weight.

To protect the batteries and transmitter from excessive reductions in temperature, a thermally insulated inclosure is required. Likewise, the motor and electrical contacts for keying the transmitter should be protected from icing and other unfavorable conditions. We have found that a box with cellular walls made up of several layers of corrugated paper is best for this purpose. This inclosure is built up of several layors of corrugated paper glued together. The thermal insulation secured in this way is far superior to that provided by balsa-wood containers. This is shown by the following values which give the interior temperatures at approximately 5-minute intervals after surrounding the outside of the thermal inclosure with dry ice, −78° C. An inclosure with ¼-inch balsa-wood walls will drop to dry-ice temperature in about 12 minutes under the same conditions.

Time	Inside temperature
	°C
1:17	28
1:22	25
1:30	0
1:35	2
1:40	−6
1:45	−7
1:55	−10
2:00	−13

It should be pointed out that Cellophane inclosures of the type described previously[4] are in every way superior for maintaining the temperature of the battery inclosure at a high level in comparison with the external temperatures at the higher altitudes when the sun is above the horizon. For this reason Cellophane inclosures are still used by the authors[5] for cosmic-ray balloon equipment, which is

[2] L. F. Curtiss and A. V. Astin, Rev. Sci. Instr. 7, 358 (1936).
[3] The authors are indebted to D. M. Little and A. H. Mears of the U. S. Weather Bureau for a simple device for this purpose.
[4] L. F. Curtiss and A. V. Astin, J. Aeron. Sci. 3, 35 (1935).
[5] L. F. Curtiss, A. V. Astin, et al., Phys. Rev. 53, 23 (1938).

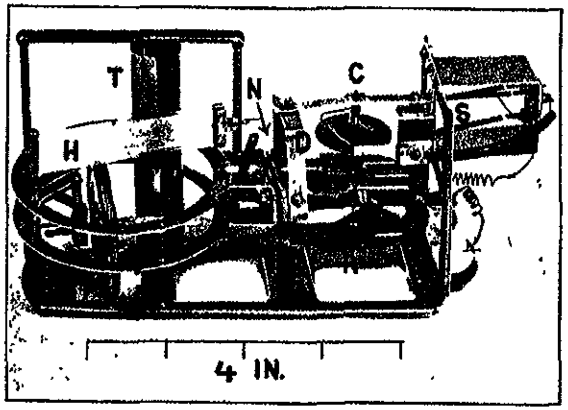

Figure 1. *Olland type radio telemeter driven by electric motor.*

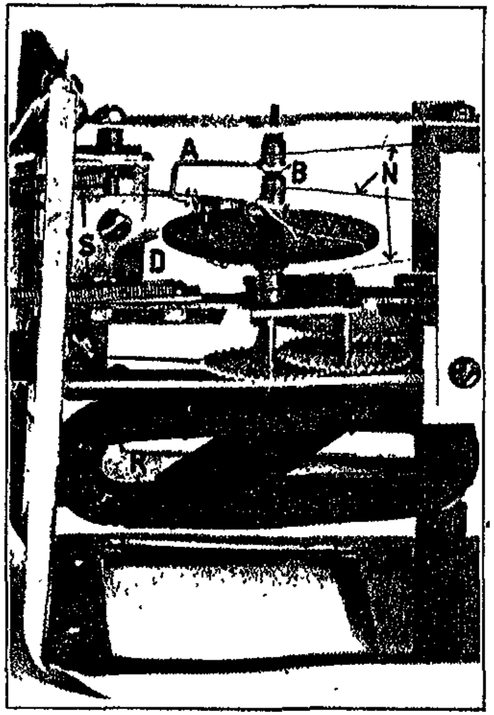

Figure 2.—*Detailed view of contact system of Olland type telemeter.*

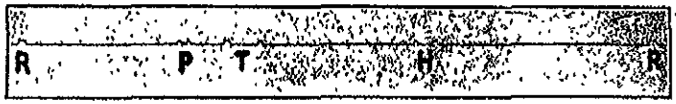

FIGURE 3. *Sample of actual tape record from telemeter, showing one Olland cycle*

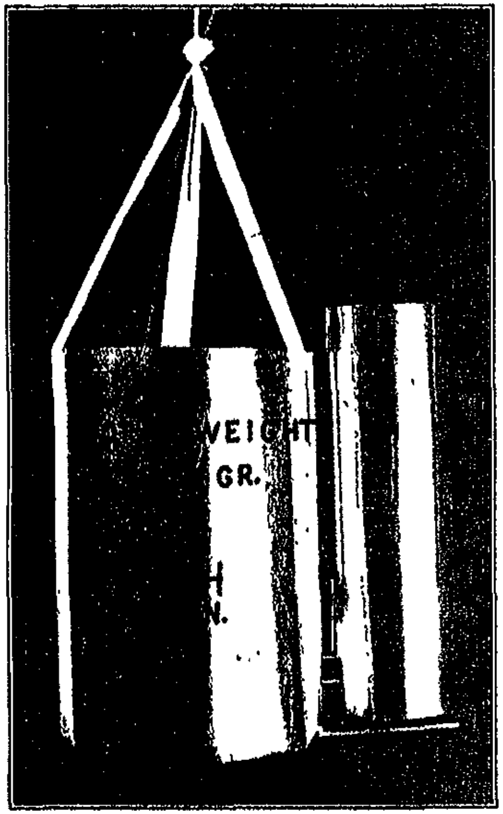

FIGURE 4.—*Assembled radio meteorograph ready for release.*

released almost exclusively when the sun is above the horizon. However, the majority of radio-meteorographic observations are made by the Weather Bureau at night, and therefore the corrugated-paper inclosure was adopted to reduce heat loss as much as possible. In this way satisfactory results have been obtained without the use of auxiliary means of heating the interior.

With such an arrangement it becomes necessary to design the telemeter so that the sensitive elements can be outside the thermal inclosure and the motor and contacts inside. Our method for accomplishing this can be explained by reference to figures 1 and 2, which are two views of the telemeter. The electric motor, of which *R* is the rotor, is mounted in a light aluminum frame used to support also the pressure, temperature, and humidity elements, *P*, *T*, and *H*. The contact system, *C*, shown in more detail in figure 2, is mounted directly on the output spindle of the motor, which turns at a speed of 4 revolutions per minute, giving four complete sets of measurements per minute. The contact system consists of a Bakelite disk, *D*, rigidly attached to the output spindle and turning with it. Imbedded radially in this disk is the platinum wire, *W*, which is in electrical contact at one end with the motor spindle. The exposed side of this wire, which is bent around and similarly imbedded in the lower surface of the disk, *D*, is polished down even with the surface of the disk. This permits electrical contact with the indicating arms without disturbing their angular position. These indicating arms, as shown at *A*, figure 2, are fastened to brass sleeves, *B*, threaded on the outside and provided with Bakelite bushings inside. Each of these arms is tipped with a double prong of fine platinum-iridium wire. The Bakelite bushings, lubricated with dry graphite, fit smoothly on the output spindle of the motor. The threaded brass sleeves are connected with their respective indicating elements by the fine Nichrome wires, *N*, each one of which passes from the free end of a sensitive element around a separate threaded sleeve, *B*, and is attached to a tension spring, *S*, anchored through an insulator to the right-hand side of the frame in figure 1. In this way linear displacements of the sensitive elements are transformed into angular displacements of the indicating arms of the contact system so that backlash is reduced and the number of moving parts is kept at a minimum. Since the spindle on which the indicating arms are pivoted is in constant rotation, and as there is some vibration in addition from the motor, no difficulty has been encountered in securing a reliably responsive action from the contact arms.

Since the electric motor has considerable power, the limit to the pressure of the tips of the indicating arms on the Bakelite disk is determined by the indicating systems. This pressure must not be so great as to cause dragging of the contact arms. By use of the platinum-iridium tips mentioned above, it has been found easy to obtain reliable electric contacts with moderate pressures. To insure the stability of the indicating systems relatively powerful elements have been used. The bimetallic spiral, *T*, (fig. 1) and the pressure diaphragm, *P*, have been designed to give strong positive action under all conditions. For the humidity element, *H*, goldbeaters skin has been used, which can be readily cut to a size of sufficient strength and has been found to be several times as responsive as human hair. Its response to changing conditions of humidity has also been found to be

To test the effectiveness of the solar shield and thermal insulation of the battery box several test flights have been made with models assembled as described above. Weakened signals of varying frequency due to drop in battery temperatures as well as slowing of the motor would be expected in the absence of sufficient protection for the battery compartment. In all flights strong signals of frequency constant to ±60 kilocycles (0.001%) were received both on the ascent and also on the descent where the rate of fall was sufficiently slow. In some of the flights the slot cut in the battery box to admit the telemoter was left open. This resulted in a slowing of the motor

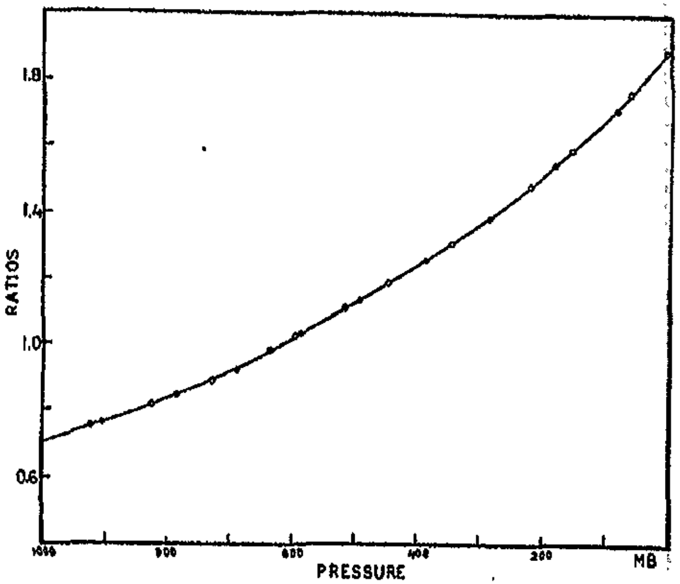

Figure 8.—*Calibration of curve of pressure element with redetermined points to show accuracy and reproducibility.*

Solid circles, original calibration; and open circles, recalibration. Maximum deviation, 1 millibar.

at the higher altitudes. When this opening was properly closed very little change in motor speed was observed.

The question of accuracy under actual working conditions is difficult to deal with in the absence of a standard for comparison. The best we can offer is a comparison of one of our records made on July 20, 1938 at 5:37 a. m. with one made for the Weather Bureau by the Navy, using a Navy type of instrument [5] released at a point about 8 miles away at 6:00 a. m. This record is shown in figure 9 plotted on an adiabatic chart. There is a consistent difference throughout in the temperatures, ours being above. At the present time we have no adequate explanation for this discrepancy. It is possible that the calibration of one or both instruments used in the above comparisons

[5] H. Diamond, W. S. Hinman, Jr., and F. W. Dunmore, Bul. Am. Meteor. Soc. 18, 73 (1937).

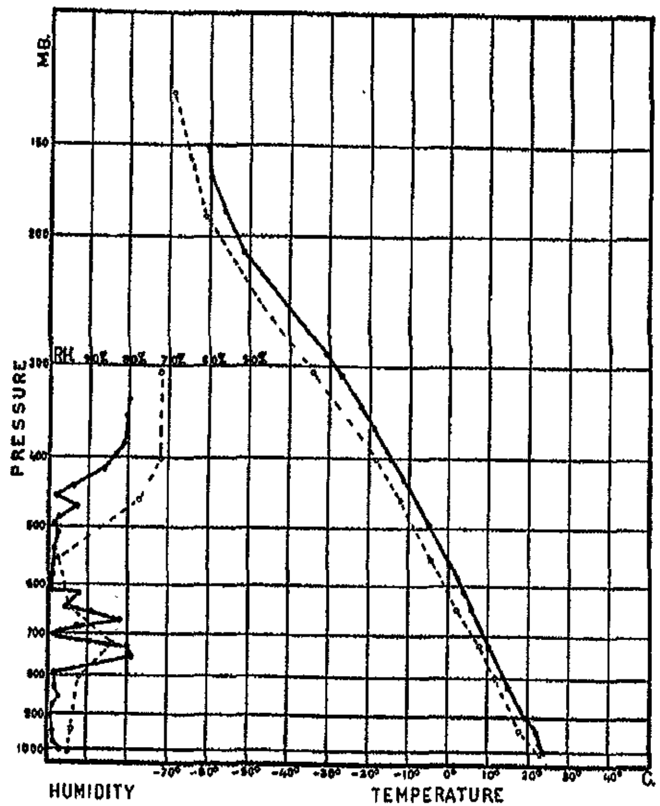

Figure 9.—*Records of Navy type instrument (dotted lines) plotted on same chart with data (solid lines) obtained by authors' instrument.*

Instruments released about the same time at points 8 miles apart.

was in error. The general agreement in trends is very satisfactory and indicates that these methods can be used reliably to obtain upper-air data.

We acknowledge the aid of the United States Weather Bureau in providing means for the construction and test of the telemeter and for suggestions regarding improvements and modifications.

Washington, September 28, 1938.

U. S. Department of Commerce National Bureau of Standards

RESEARCH PAPER RP1254

Part of Journal of Research of the National Bureau of Standards, Volume 23, November 1939

COSMIC-RAY OBSERVATIONS IN THE STRATOSPHERE WITH HIGH-SPEED COUNTERS

By Leon F. Curtiss, Allen V. Astin, Leroy L. Stockmann, and Burrell W. Brown

ABSTRACT

By a modification of a method[1] reported previously, observations of cosmic-ray intensity at high altitudes have been made.

A Neher-Harper circuit has been used with relatively large Geiger-Müller counters so that 2,000 to 3,000 counts per minute could be recorded by means of radio equipment sent aloft attached to free balloons. The counters were standardized in terms of the radiation from 1 mg of radium at a distance of 1 m, and the maximum cosmic-ray intensity was found to be 0.55 percent of this intensity. This maximum was found to occur at an atmospheric pressure of 60 millibars. A very low intensity at pressures of about 5 millibars, reported in the previous paper, was not observed in any of the 15 ascents in which the data reported in the present paper were obtained.

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I. INTRODUCTION

In a previous paper[2] results were given of cosmic-ray observations in the stratosphere, using small, low-speed Geiger-Müller counters. The counters were carried aloft by sounding balloons, and the counts were broadcast to a receiving station on the ground by a radio transmitter also carried by the balloons. The active volume of each counter was approximately 1 cm^3, and the counting rate at the altitude of maximum intensity was approximately 60 per minute. Since the counting rate on the ground was less than one per minute and since the time required for the equipment to reach the altitude of maximum counting rate was only 90 minutes, the results were subject to considerable statistical fluctuation.

[1] Phys. Rev. 53, 23 (1938).

[2] L. F. Curtiss, A. V. Astin, L. L. Stockmann, B. W. Brown, and S. A. Korff, Phys. Rev. 53, 23 (1938).

In the present investigation the size of the counters has been increased to give approximately a thirtyfold gain in counting rate. This increase was sufficient to make the curves of counting rate versus pressure comparable in smoothness to those obtained from observations with ionization chambers. The great advantage of the counter method over the ionization chamber for cosmic-ray exploration of the upper atmosphere is that the balloons do not have to be recovered in order to obtain the data.

A further improvement in the present investigation over earlier work has been the standardization of each counter in terms of gamma radiation from radium.

II. DESCRIPTION OF BALLOON EQUIPMENT

1. COUNTERS

The general construction of the Geiger-Müller counter tubes used in this investigation may be seen in figure 1, which shows a typical tube. The outer electrode, or cathode, is a copper tube about 1 cm in diameter and 16 cm in length. The anode is a No. 42 steel wire with glass sleeves at the ends to serve as guards, after the manner described by Cosyns and de Bruyn.[3]

To secure a broad and level plateau, it has been found necessary to clean the electrodes by sputtering. The treatment employed is a modification of the method described by Diffenbach, Lifshutz, and Slawsky.[4]

The electrodes are connected to a transformer adjusted to produce a steady glow between the electrodes in an atmosphere of hydrogen at a pressure equivalent to a few millimeters of Hg. The hydrogen is changed frequently and the sputtering permitted to continue for from 12 to 24 hours. Care must be taken during the sputtering to prevent a deposition of metal on the glass surface so that the insulation may not be ruined.

After sputtering, the counters are filled and sealed with a mixture of about 10 parts of argon to 1 part of hydrogen at a pressure of approximately 6 cm of Hg. The counters so treated and filled require about 575 volts for their operation and have an approximately constant counting rate for any voltage, either higher or lower, within 50 volts of this value.

2. INTEGRATING CIRCUIT

The wiring diagram of the amplifier and integrating circuit associated with the counter is shown in figure 2. The pulses from the counter are fed to a high-speed stage of the Neher-Harper[5] type.

The major purpose of this stage is to restore rapidly the counter to its normal state. The second stage serves to level the pulses, since those coming from the first stage may have widely different magnitudes. The tube is arranged for a sharp cut-off, so that all input pulses, regardless of their magnitude, give the same output signal. The third stage rectifies the pulses and the rectified current charges the capacitor, *C4*. When the charge on *C4* is sufficient to flash the neon tube, *N*, a signal is transmitted through the final stage, actuating

[3] Acad. roy. Belg., Bul. classe sci. 20, 271 (1934).
[4] Phys. Rev. 52, 1231 (1937).
[5] Phys. Rev. 49, 940 (1936).

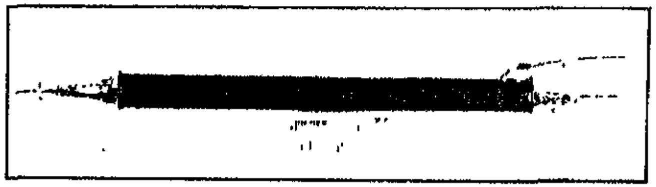

Figure 1.—*Geiger-Muller tube counter used with radio-balloon equipment.*

the relay, Z. The relay is arranged to key the radio transmitter. The flashing voltage of the neon tube and the size of capacitor $C4$, as well as the magnitude of the leveled pulses, determine the number of counts or discharges in the Geiger-Müller tube necessary to actuate the relay. This number has varied from 35 to 100 in the 15 units that have been used for stratosphere soundings.

The integrating circuit, which is similar in some respects to one described by Johnson,[8] is essential to prevent a large increase in the keying rate of the transmitter when the counting rate is stepped up. This is because of speed limitations of the ground recording system. In the earlier work of the authors with low-speed counters the integrating circuit was not essential. It was found that with the amplifying and integrating circuit of figure 2, higher counting rates could be handled than could be provided with counters of the size described

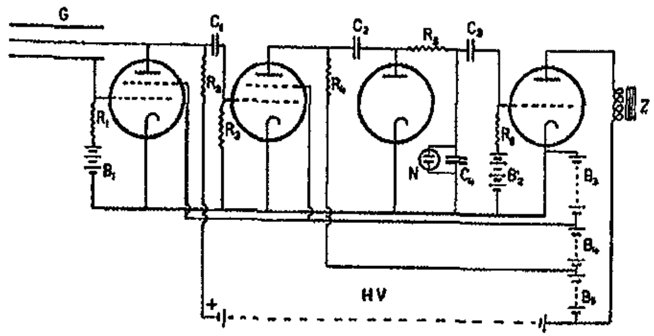

FIGURE 2.—*Wiring diagram of integrating circuit used with tube counters.*

G=tube counter
C_1=0.0001 μf
C_2=0.0001 μf
C_3=0.01 μf
C_4=0.01 μf.

R_1=20 megohms
R_2=5 megohms
R_3=1 megohm
R_4=1 megohm
R_5=20 megohms
R_6=10 megohms

N=neon lamp
B_1=6 volts
B_2=12 volts
B_3=22.5 volts
B_4=90 volts
B_5=135 volts

in the previous section. Accordingly two counters were connected in parallel, thus approximately doubling the counting rate.

The characteristic of a typical counter and its associated circuit as a function of voltage applied to the counter is shown by figure 3. The fact that the counting rate is constant over a 95-volt range shows that not only does the counter have a satisfactory plateau but that the leveling stage of the amplifier is operating satisfactorily. Tests of the linearity of the integrating circuit have been made in three different ways with equally satisfactory results in each case. With different intensities of radiation applied to the counter, the flashing rates have been compared to the counting rates of a Cenco counter connected directly to the output of the first stage of the amplifier so as to record the impulses of the counter directly. The number of impulses per flash was the same for all counting rates tested. The second test consisted in placing radium samples of different known intensities at a fixed distance from the counter tube. The ratios of the differences in counting rates were the same as ratios of the differences in

[8] Phys. Rev. 53, 914 (1938).

strengths of radium sources. The third test involved a fixed quantity of radium at different distances from the counter. The ratios of the differences in counting rates coincided with the expected differences from inverse-square law calculations.

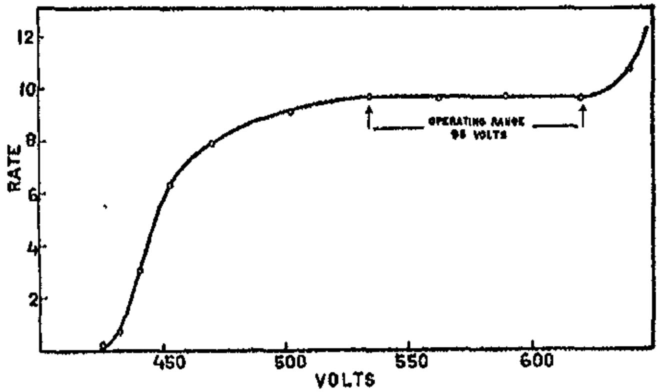

FIGURE 3.—*Operating characteristic of typical counter showing variation of counting rate with applied voltage.*

The resolving time and maximum counting rate of the circuit were determined by the method suggested by Schiff.[7]

In figure 4 the solid line shows Schiff's theoretical curve of counting rate, (N/T), times resolving time, (τ), plotted against the ratio of total

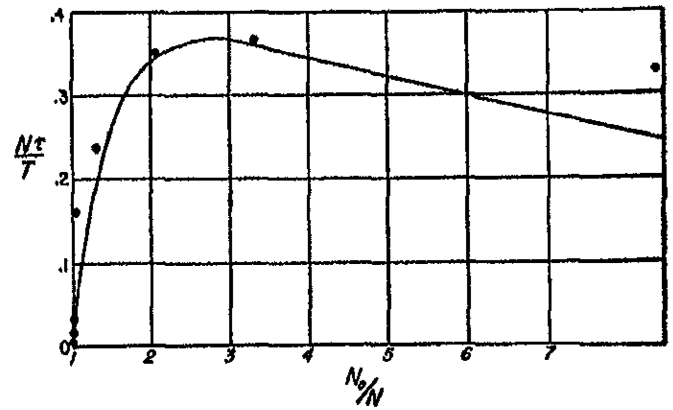

FIGURE 4.—*Efficiency characteristic of counter circuit.*

N=Total number of pulses counted in time T.
N_0=Total number of pulses in counter in time T.
τ=Resolving time of circuit.

particles through the counter, (N_0), to the number recorded by the counter, N. The maximum counting rate occurs when $N_0/N=e$ and the resolving time is determined from the value of the maximum, $N\tau T/T=1/e$. The circles show the experimental points which were

[7] Phys. Rev. 50, 83 (1936).

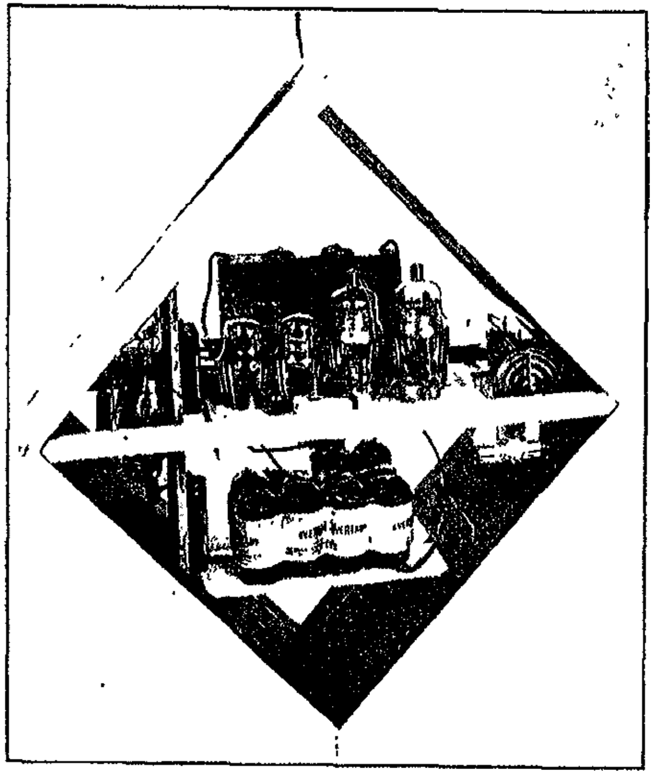

FIGURE 5.—*Complete assembly including counter tubes, vacuum-tube circuit, barograph, radio transmitter, and necessary batteries.*

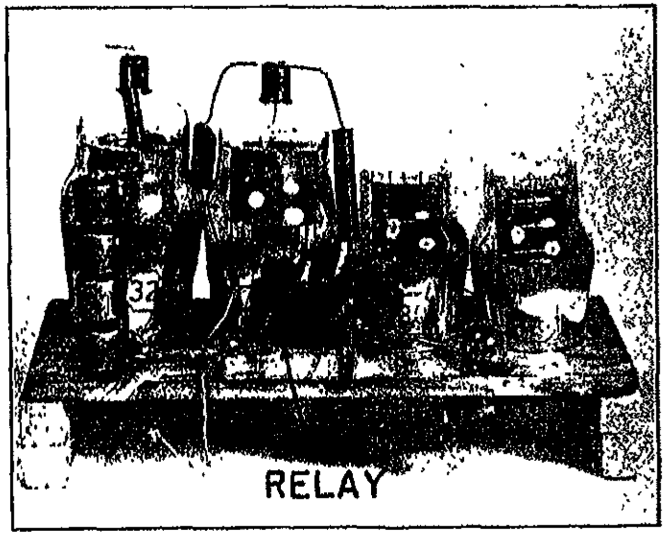

FIGURE 6.—*Amplifying and integrating assembly.*

obtained by observing the counting rates when radium sources of different known intensities were placed at a fixed distance from the counter. The values of N_0 were fixed from the lower counting rates where a linear relation was observed between counting rate and intensity of the source (after allowing for the blank counting rate). Theory and experiment show the maximum counting rate at the same value of N_0/N, but differ in other respects, as shown in the figure. These differences might occur if the resolving time, τ, were not constant, as was assumed by Schiff. The value obtained for τ from this set of data was 9×10^{-4} second. In the observations on cosmic rays the counting rates never exceeded a value for $N\tau/T$ of 0.05, for which values N_0/N was unity, within a few percent.

3. BAROGRAPH

The barograph used in this investigation was of the same type as that used in the earlier work and has been described in detail elsewhere.[5] The sensitive element of the barograph was a small aneroid capsule of copper-beryllium alloy. The revolving contact arm of the barograph was driven by a small impulse-type motor which was adequately powered by a 1½-volt "pen-light" battery. Pressures could be determined to within ±2 millibars over the range of pressures 1,000 to 5 millibars. The possible error due to temperature variations of the barograph has been carefully investigated and found to be less than the precision of reading over the entire range.

4. RADIO TRANSMITTER

The radio transmitter was also the same as that used in the earlier work. It consisted of two type 30 tubes in push-pull oscillating at 13.5 megacycles and powered by a 135-volt plate supply. Keying was accomplished by short-circuiting a cathode biasing resistor. The resistor was sufficiently large so that the circuit would not oscillate unless the resistor were shorted. Consequently, the transmitter was silent except for the relatively short times of keying, an important factor in keeping the battery requirements at a minimum.

5. BATTERIES

The voltage supply for the counter (*B5*, fig. 2) was obtained from Eveready X-180 units. Each one of these units supplies 45 volts and weighs but 2 ounces. The plate voltage for the tubes of the amplifier, as well as for the transmitter, was obtained from Burgess V40 units. Each of these units furnishes 45 volts and weighs about 3.5 ounces. The filaments of all tubes required 2 volts for their operation, which was obtained from ordinary flashlight batteries. It was found most convenient to connect two filaments in series and heat them with the current from three flashlight batteries in series.

6. ASSEMBLY

The assembled balloon equipment is shown in figure 5. The four tubes of the amplifier and integrating circuit, a separate view of which is shown in figure 6, are in the center of the picture. The plate-supply

[5] Phys. Rev. 53, 23 (1938); J. Research NBS 22, 97 (1939) RP1169.

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batteries for these tubes, as well as for the transmitter, are just behind them. In front of the amplifier are the neon tube and relay (Z, fig. 2) for keying the transmitter. The second counter has been removed but is normally installed just in front of the amplifier. Below the amplifier may be seen the high voltage supply for the counters. To the right of the amplifier is the barograph unit, and to the left is the radio transmitter. The antenna and attachment cord to the balloons are shown in the upper part of the picture.

The crate in which the equipment is mounted consists of a balsa-wood frame with double Cellophane lining for heat insulation. The front and back sides of the crate are removed in figure 5. The interior Cellophane surface is lined with black paper, which serves both as a heat absorbing surface and as a light shield for the counters. Tests on the interior temperatures of such enclosures when in the stratosphere in daytime have shown the temperature to be within ±15° C of 25° C.

It was found that moisture enclosed within the frame when the crate was sealed frequently condensed on parts of the insulation and interfered with the proper operation of the equipment. This trouble was eliminated by coating the insulating surfaces well with Superla wax and enclosing some calcium chloride in a cheesecloth bag within the crate when it was sealed.

The weight of the completely assembled balloon equipment ready for attaching to the balloons was approximately 2,200 g.

7. BALLOONS

The counter equipment and radio transmitter were carried aloft by five or six Dewey and Almy latex balloons, model No. 700. These balloons have an uninflated diameter of about 4 ft and will expand to approximately 19 ft before bursting. The balloons were inflated with hydrogen to have a free lift of approximately 600 g per balloon. This gave an ascension rate in excess of that normally used in stratosphere soundings, but it has been the authors' experience that higher altitudes are obtained with higher ascensional rates.

The balloons were attached to strings of different lengths to reduce contact of the balloons with each other. This was found desirable in preventing both premature and simultaneous bursting of the balloons.

III. GROUND EQUIPMENT

The receiver used in this work was a commercial 5-meter superregenerative type. A detector tube of the grid current type was added to the receiver. In its unexcited condition the regenerative noise of the receiver suppressed the plate current of the detector tube. A signal entering the receiver suppressed the regenerative noise and caused an increase in the current of the detector tube. The receiver was very insensitive to noise, since only a definite pulse of waves of the frequency to which the receiver was tuned would suppress the regenerative noise and thus release the output current. Ordinary static was quite ineffective, since it mainly added to the regenerative noise. The disadvantage of the circuit was that a signal of at least about one-tenth second duration was necessary to actuate the receiver. This, of course, limits the number of signals per second which the receiver can handle and explains why it was essential to use an integrating circuit on the balloon equipment for high-speed counters.

The method of actuating the recorder is shown in figure 7. The plate current from the detector tube enters at the terminals marked "to amplifier" and passes to the relay. A signal in the receiver increases the current through the meter, M, and actuates the relay, which in turn controls the grid potential of the gas-filled 885 triode. The plate current of the 885 tube passes through an electromagnet which controls a recording stylus.

The complete ground equipment is shown in figure 8. The receiver is to the right; the plate-current meter of the detector circuit, the 885 tube, and the power supply are in the center; and the waxed-tape record and recording stylus to the left. Perforated tape, moved by a sprocket which is driven by a synchronous motor, is used to secure uniform motion of the tape.

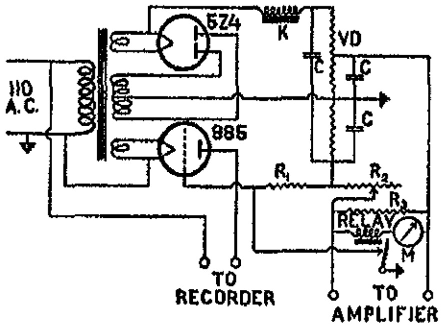

FIGURE 7.—*Wiring diagram of detector circuit used with superregenerative receiver to actuate records.*

VD=25,000 ohm voltage divider
K=30 henry choke
C=8 μf
R_1=0.5 megohm
R_2=50,000 ohms
R_3=100,000 ohms

A sample record is shown in figure 9. The upward breaks in the horizontal line on the tape correspond to signals received from the radio transmitter. The double breaks marked "reference doublet" correspond to regular keyings of the transmitter by the motor-driven contact arm. These reference marks are received approximately four times per minute. The break marked "pressure" corresponds to a keying of the contact arm by a contact point connected to the aneroid capsule. The ratio of the distance between a reference doublet and pressure signal to the distance between two reference doublets gives a measure of the pressure. The narrow breaks in the horizontal line marked "cosmic rays" correspond to keyings of the transmitter by the integrating circuit. These signals are readily discernible from the barograph signals by both their width and position. The regularity of the spacing between the cosmic-ray signals is an indication of the extent to which the random fluctuations in the individual discharges of the counter are smoothed out by the integrating circuit.

IV. RESULTS

A total of 15 successful sets of observations were obtained with equipment of the type just described, between July and November 1938. A typical record, which was obtained July 22, is shown in figure 10. The record shows excellent agreement in results obtained during both the ascent and descent of the balloons. The ordinate scale shows the actual number of discharges per minute in the counters, which for this particular equipment was 48 times the flashing rate of the neon tube in the integrating circuit, or 48 times the number of cosmic-ray radio signals received at the ground station. The number of counts required to flash the neon tube was determined by means of a Cenco counter.

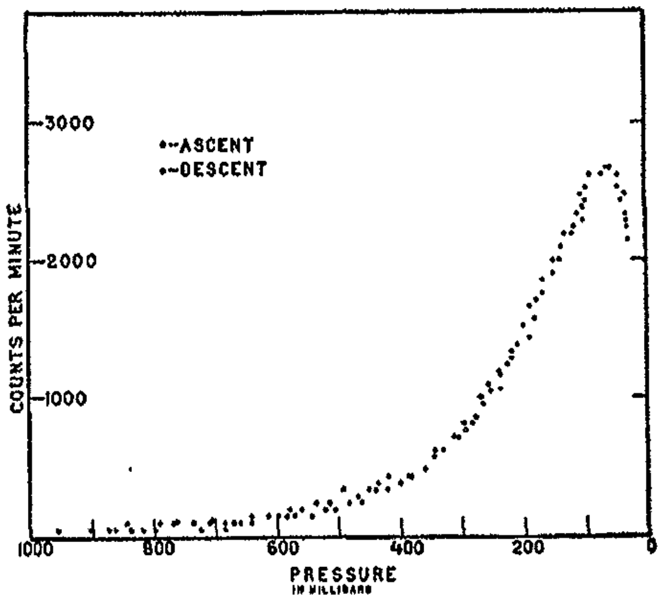

FIGURE 10.—*Data obtained on a single ascent and descent, showing counts per minute plotted against the atmospheric pressure in millibars.*

A summary of all the results obtained is given in table 1. Column 1 of the table gives the date on which the observations were made, and column 2 gives the number of counts necessary to flash the neon tube of the integrating circuit. Column 3 shows the number of counts produced in each set of equipment by 1 mg of radium placed 1 m from the counters. Although the counters were made as nearly alike as was reasonably possible, there are evidently real differences in the sensitivities of the counters. These differences are made apparent by comparing the standard deviation of the values of column 3 from their mean with the deviation one would expect if an equivalent number of observations were taken with a single counter under constant conditions. The expected standard deviation of a single observation of N events, distributed at random (that is, according to

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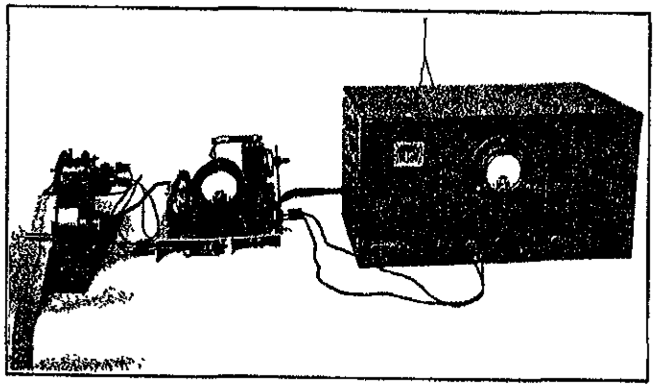

FIGURE 8.—*Complete receiving equipment.*

The superregenerative receiver is on the right. The detector circuit operated by the output of the receiver is in the center. The tape recorder is on the left.

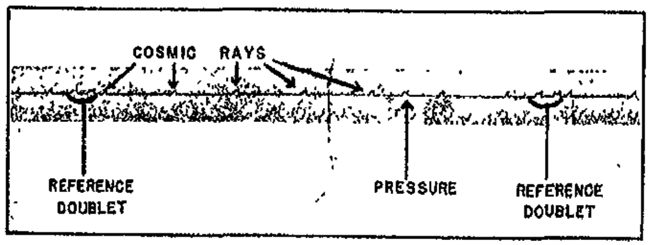

FIGURE 9.—*Sample of actual record on waxed tape.*

Poisson's law), is $N^{1/2}$. The total number of events or counts involved is 3,320×15×5=249,000 (since each of the 15 values in the table represents the average over 5 minutes). The expected standard deviation of this value would be 498 for the 75-minute period, which would give an expected, standard deviation of 7, in the average counting rate, per minute. This expected value of 7 for a single counter is so much less than the actual standard deviation, 110, of the 15 counters, from their mean that there is little doubt that real differences exist in the sensitivities of the counters.

TABLE 1.—*Summary and analysis of observations*

Date (1938)	Average counts per signal	Standardization, counts per minute for 1 mg of Ra at 1 m	Maximum observed counting rate in upper atmosphere, counts per minute	Pressure at altitude of maximum counting rate	Ratio of maximum counting rate to standard counting rate	Ratio of counting rate at 200 mb to maximum counting rate	Ratio of counting rate at 500 mb to maximum counting rate	Blank counting rate per minute	Pressure at maximum altitude attained	Ratio of counting rate at maximum altitude to maximum counting rate
1	2	3	4	5	6	7	8	9	10	11
				mb					*mb*	
7/13	40 6	3,830	2,110	60	0.55	0.60	....	....	16	0.79
7/15	52.0	3,640	2,340	60	.07	.62	....	....	18	.91
7/22	47.6	3,240	2,620	60	.81	.58	....	....	28	.86
7/25	40.1	2,690	4,160	55	.02	.02	....	....	15	.76
7/28	102.5	2,970	1,540	60	.02	.60	....	....	a 12	.73
8/17	49.6	3,120	1,660	50	.59	.59	0.12	25	a 8	a .88
8/18	72.8	3,260	1,610	60	.49	.59	14	36	20	.89
9/1	49.1	3,290	1,690	55	.48	.63	.07	34	a 12	a .88
9/11	65.8	3,750	1,970	60	.53	.07	.07	130	a 8	a .75
9/12	63.6	3,490	1,070	60	.55	.57	.07	32	a 10	a .87
9/13	60.9	3,980	1,600	60	.42	.67	.04	140	a 10	a .77
9/17	46.0	3,680	1,670	55	.47	.68	.08	90	a 10	a .80
9/25	63 0	3,000	1,730	50	.50	.62	.04	60	a 10	a .84
9/28	50.0	2,000	1,440	60	.56	.57	.10	59	a 10	a .82
11/16	61.0	3,660	1,650	65	.45	.62	.11	91	36	.93
Average	....	3,320	1,810	58	b 0.55	0.61	0.084	....	a 10	a 0.82
Standard deviation	....	110	85	1	b 0.023	0.012	0.033	....	....	0.02

a Only these values averaged.
b Omitting July 22, 1938, average=0.53; standard deviation=0.016.

In column 4 of table 1 is listed, for each sounding, the maximum observed counting rate obtained during the flight; and column 5 gives the average pressure, in millibars, observed at the time of maximum counting. Although the pressure could be read to the nearest 2 millibars, the pressure at the maximum counting rate could be estimated to only the nearest 5 millibars. The average value of the pressure at which the counting rate is a maximum is 58 millibars, which corresponds to an altitude of 69,500 ft. The percentage standard deviation of the values of column 4 from their average, 4.7 percent, is only slightly greater than for column 2, 3.3 percent. An increase of about this amount is not unexpected because of the increased uncertainties of measurement. It was hoped that by taking account of the differences in sensitivities of the various counters the deviations could be reduced. Accordingly, in column 6 are listed the ratios of the maximum counting rates of column 4 to the standard counting rates of column 3. These ratios, with one exception, are noticeably more self-consistent than the maximum counting rates. Omitting the data of July 22, the percentage standard deviation of the ratios from their mean is less than 2 percent; including it the deviation is 4 percent. This one ratio is sufficiently out of line with the other 14 values to justify one of two conclusions, (1) something was wrong with the equipment, or (2) the cosmic-ray intensity at 60 millibars was abnormally high on July 22, 1938. There was no obvious inadequacy in the performance of the equipment, as is evident by referring back to figure 10, which is the record of the flight for this date. On the other hand, an examination of records from other laboratories has shown no departures from normal on this date of either the cosmic-ray intensity at sea level, or magnetic or solar phenomena. Accordingly, there is no reason to choose one conclusion over the other.

In column 7 are shown the ratios of the maximum counting rates to the counting at 200 millibars. The consistency of the data of this column merely indicates that the curves for all flights, such as shown in figure 8, had the same general shape. The agreement would probably be still better were it not for the facts (1), that counting rate was changing rapidly with time, and (2), that the counting time was extremely short. The data for 500 millibars, which are shown in column 8, are very erratic for not only are the counting rates varying and the counting period short, but the counting rate is low and appreciably influenced by the blank counting rate.

The blank counting rate represents the spontaneous discharge rate of the counter in the absence of radiation. It was determined by observing the counting rate in an iron shield of sufficient thickness to absorb gamma radiation and then subtracting from this value the number of counts expected from cosmic rays. Kolhörster and Janossy [9] have estimated the cosmic-ray intensity at sea level as 0.6 particle per cm^2 per minute, which value gives 19 counts per minute for our counters. This counting rate was then subtracted from the counting rates observed in the iron shield, and the remainder corresponds to the blank counting rates listed in column 9 of the table 1.

The minimum pressure attained in each flight is listed in column 10, and the ratio of counting rate at this pressure to the maximum counting rate is given in column 11. The minimum pressures recorded in nine of these flights differ by no more than the precision of reading, so the counting rates at minimum pressure have been averaged for these flights. This gives a counting rate at 10 millibars equal to 0.82 percent of the maximum counting rate. The very low counting rate obtained in one high-altitude flight in our earlier work has not been repeated, so it is probable that the earlier data were erratic.

Inasmuch as the barometric capsules showed uncertainties as large as ±2 millibars during calibration, the error at 10 millibars may be as large as ±20 percent. The altitude corresponding to 10 millibars is approximately 101,000 ft, and the uncertainty in reading the barograph means that the actual altitude attained may differ from this figure by approximately ±5,000 ft.

An estimate of the ratio of the maximum cosmic-ray intensity to sea-level intensity can be obtained by making use of the data of

[9] Z. Physik 93, 110 (1935).

Kolhörster and Janossy referred to above. These data gave a sea-level counting rate of 19 for our counters, which is one ninety-fifth of the average value of the maximum counting rate, 1,810 per minute. This ratio is not directly comparable to similar ratios obtained by ionization chambers because of the directional effect of the counters. At sea level, where the cosmic rays are predominantly vertical, the effective area of the counters is essentially the product of the length and diameter. At high altitudes, however, observations such as those made in the stratosphere balloon *Explorer II* [10] have shown the vertical and horizontal components to be nearly equal. With such a directional distribution the average effective area of the counters used in our work has been found by integration to be very nearly 50 percent of the effective area to vertical radiation. This means that the ratio of our maximum count to ground count—that is, 95—should be approximately one-half the same ratio obtained by ionization-chamber measurements.

In the standardization of the counters with gamma radiation the radium was placed in the plane of the axis of the counters and at right angles to their axis, so that the effective area exposed to the gamma radiation was approximately one-half the effective area for vertical radiation or very nearly the same as the effective area to nondirectional radiation. Because of this it is believed that a reliable estimate of the maximum cosmic-ray intensity has been obtained by use of the standardized counters. This gives, as previously shown, a maximum counting rate equivalent to 0.54 mg of radium at a distance of 1 m.

WASHINGTON, August 8, 1939.

[10] W. F. G. Swann, G. L. Locher, and W. E. Danforth, Phys. Rev. 51, 389 (1937).

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FREQUENCY METER FOR USE WITH GEIGER-MÜLLER COUNTER

By Leon F. Curtiss and Burrell W. Brown

ABSTRACT

An improved circuit is described for reading the rate of pulses from a Geiger-Müller counter.[1] Based on the usual procedure of leveling and rectifying the pulses to charge a condenser, the improvements concern a bridge-type vacuum-tube voltmeter to read the voltage on the condenser and an arrangement to compensate parasitic potentials developed in the rectifier for the pulses. An adequate source of potentials from one small transformer is described, which renders the circuit useful in portable instuments. Particular care has been taken to design a circuit that is independent of the voltage of the alternating-current mains from which the circuit is operated. A modification of the circuit for rapidly decaying sources is also described.

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I. INTRODUCTION

The use of Geiger-Müller counters can be extended considerably if the accessory equipment for their operation can be made light enough to be readily portable and at the same time thoroughly reliable. Many attempts have been made to achieve this result, but in general the equipment that has been found satisfactory is too heavy, and that which has been sufficiently light is not reliable, since their components are operated beyond their normal capacity. Now that the vapor-filled Geiger-Müller counters have been shown to be quite [2] trustworthy when simple precautions are taken in preparing them, the way is open for the development of accessory circuits, operated directly from alternating-current mains, which are of moderate weight and in which all parts are operated within their specified rating. There is presented here a description of one such circuit that has given very good performance. Completely assembled in a metal case, the device weighs slightly less than 15 pounds.

[1] L. F. Curtiss, NBS J. Research 23, 479 (1939) RP1246.
[2] F. J. Davis and L. F. Curtiss, NBS J. Research 29, 405 (1942) RP1509.

II. CIRCUIT FOR GAMMA-RAY EXPOSURE METER

A diagram of the circuit for operating and reading the output of a Geiger-Müller counter is shown in figure 1. Since one object is to reduce weight, the power transformer selected is the smallest of those made commercially for the operation of radio sets. The secondary, which is center-tapped, delivers a total a-c voltage of about 650 volts and will carry about 40 milliamperes. In addition, it has a 5-volt and a 6.3-volt filament winding. The problem of obtaining about 1,200 volts and 150 volts d-c from this transformer is solved by using one-half the secondary to provide the positive power-supply voltage and the complete secondary, connected to a voltage-doubling circuit

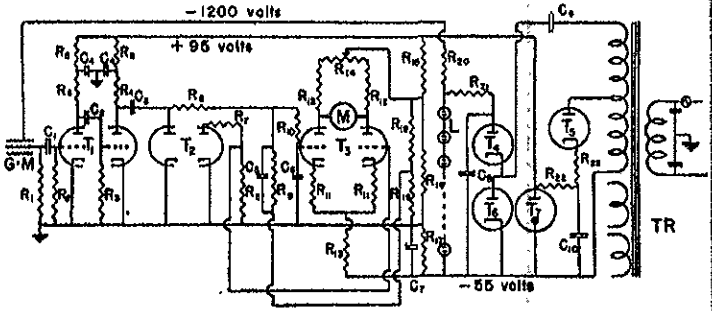

FIGURE 1.—*Wiring diagram for gamma-ray exposure meter.*

M=0 to 200 μa; L=1/10-watt neon bulbs; G-M=vapor-filled Geiger-Müller counter, T_1=6SL7; T_2=VR15[illegible]; T_3=6F8; T_4=6Z4; T_5, T_6=6X5; T_7=VR150; TR=Stancor, P-6010; C_1=100 μμf, mica; C_2=250 μμf, mica; C_3=60 μμf, mica; C_4, C_7=8 μf, electrolytic; C_5=4 μf, paper; C_6=0.1 μf, paper C_8=1 μf, 2000 volts, C_9=2 μf, 1,000 volts; C_{10}=16 μf, electrolytic; R_1=1 megohm; R_2, R_3, R_4=0.1 megohm; R_5=10,000 ohms; R_6, R_7, R_{20}=2 megohms; R_8, R_9=5 megohms; R_{10}, R_{11}=3 megohms; R_{11}, R_{12}=2,000 ohms, R_{13}, R_{15}, R_{16}, R_{17}=20,000 ohms; R_{13}=60,000 ohms; R_{14}, R_{21}=5,000 ohms; R_{18}=100,000 ohms; R_{19}=3,500 ohms.

as shown, to provide the higher negative voltage. Half-wave rectification is used in both cases. The lower voltage, to supply the plate voltages of the amplifying and indicating circuit, is stabilized by a VR-150 voltage-regulator tube. The higher voltage, to provide the operating potential for the Geiger-Müller counter, is stabilized by a series of 1/10-watt neon lamps that has been thoroughly aged by operation on alternating current for at least 2 weeks. It has been found that lamps so aged maintain the same constant voltage across their terminals for very long periods of time. A voltage-stabilizing circuit connected as shown will show fluctuations unreadable on a 1,500-volt electrostatic voltmeter when the primary voltage of the transformer is varied from 100 to 130 volts. The actual change may be as much as 5 to 10 volts. This is sufficient regulation for a Geiger-Müller tube with reasonably good plateau, and will produce a negligible change in the indication of a good counter.

When using Geiger-Müller counters of the vapor-filled type very little amplification and leveling of pulses is required. Therefore, the relatively simple circuit shown is entirely adequate. The first triode section of T_1 provides the required amplification of the negative pulse from the counter G–M. These pulses are applied to the grid of this triode through a conventional resistance-capacity coupling. The

pulses at the plate, now positive, are sufficient to saturate the second triode stage, which is operated at zero bias. Therefore, the positive pulses applied to the grid of this triode result in grid rectifications so that the main pulses at the plate of this stage are positive, somewhat broadened, and of equal height and width. As the triode side of C_3 becomes positive, the diode side accumulates an excess of positive charge which flows through the diode to ground; thus, after the return of the plate of the second half of T_1 to normal potential, a negative charge is left at the diode plate of C_3, which flows through R_8 to the RC circuit, charging it negatively. R_8 serves to prevent the pulses from bypassing the diode by way of C_5 without rectification. Under these conditions, an equal charge of negative sign is applied to the condenser, C_5, for each pulse. Since condenser C_5 has a resistor, R_9, connected across it, the potential across the condenser will rise to a constant value for a constant rate of pulses from the Geiger-Müller counter.

Therefore, to obtain a reading proportional to the rate of pulses at the Geiger-Müller counter, a reliable electronic voltmeter is required to measure the voltage across condenser C_5. This is provided by the twin-triode T_3, with the two sections connected in a bridge circuit with a microammeter, M, connected between the plate terminals of the two sections. These triodes are operated at a negative bias provided through high-resistance cathode resistors R_{12} and R_{11} in such a way that the readings of the meter are fairly independent of the characteristics of the triode sections. A balancing potentiometer, R_{14}, is provided to adjust the circuit for the residual effects of differences between the triode sections. This adjustment is made with the Geiger-Müller counter disconnected. In general, it need only be changed when replacing a tube.

To balance out certain parasitic potentials arising from the use of a diode to rectify the pulses from the counter, the two grids of the twin triode, T_3, are connected in identical circuits, each to one section of the twin diode, T_2. In addition, it is desirable to compensate the blank counting rate of larger Geiger-Müller tubes so that the meter reads zero in the absence of a source of radiation. This is done by applying a slight positive bias to the grid of the voltmeter tube attached to the condenser, C_5, by a bleeder circuit composed of resistors R_{18} and R_{19}. This adjustment can be made by proper selection of R_{18} and R_{19} for a given Geiger-Müller tube and need be changed only when replacing this tube.

The resultant circuit has the following desirable characteristics:

1. The reading of the meter, M, is quite accurately proportional to the rate of pulses from the counter. The calibration of intensity of radiation versus the reading of the meter is a straight line passing through the origin in a correctly adjusted circuit. This is shown in figure 2, which is a typical calibration for one of these circuits.

2. The reading of the meter is practically independent of the *a-c* supply voltage in the range from 100 to 130 volts. This 30-volt change produces less than a 2 percent change in the reading of the meter.

3. No component is operated above its normal rating, so that failure of vacuum tubes, condensers, and resistors is reduced to a minimum.

4. All potentials, both positive and negative, are obtained from one transformer, thus reducing the weight and with no sacrifice in performance.

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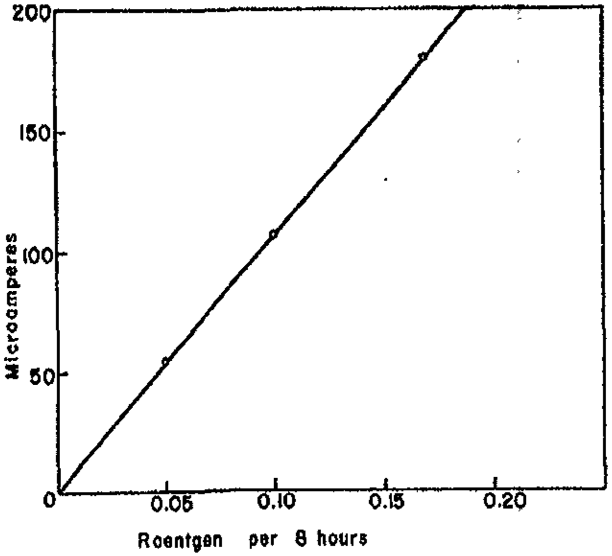

FIGURE 2.—*Calibration curve for the gamma-ray exposure meter.*

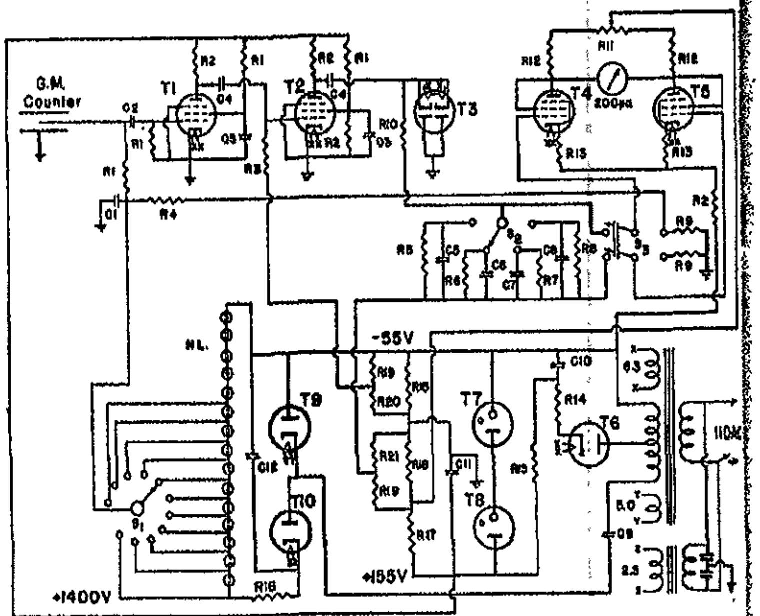

FIGURE 3.—*Wiring diagram for circuit for rapidly decaying sources.*

T_1, T_2=6AC7; T_3=6H6; T_4, T_5=6K6; T_6=6X5; T_7, T_8=VR105; T_9=5Z4; T_{10}=2X2; C_1=0.02 μf; C_2=60 μμf, 2,500 volts; C_3=0.1 μf; C_4=60 μμf, C_5=4 μf; C_6=2 μf; C_7=1 μf; C_8=0.5 μf; C_9=1 μf, 1,000 volts; C_{10}=20 μf; C_{11}=8 μf; C_{12}=1 μf, 2,000 volts; R_1=0.1 megohm; R_2=50,000 ohms; R_3, R_4=60 megohms; R_5, R_{10}=0.2 megohm; R_6=0.67 megohm; R_7=2 megohms; R_8=6 megohms; R_9=60,000 ohms; R_{11}=5,000 ohms, R_{12}, R_{13}, R_{20}=20,000 ohms; R_{14}=1,000 ohms; R_{15}=5,000 ohms; R_{16}=2 megohms; R_{17}=25,000 ohms; R_{18}=10,000 ohms; R_{19}=100,000 ohms.

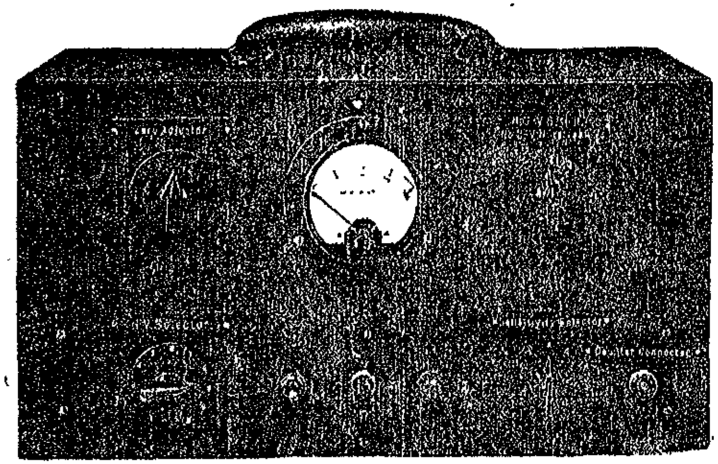

FIGURE 4.—*View of panel of counting-rate meter for use with Geiger-Muller counter.*

III. ADJUSTMENT OF SENSITIVITY

Since the first twin triode operates as a unit to provide the required pulses for rectification, the only circuit change required to alter the reading of the meter, M, for a given pulse rate, is that of changing the capacitance of C_3. Increasing this value for C_3 will increase the quantity of charge per pulse applied to C_5. This means of adjustment is adequate for such purposes as to adjust the meter reading so that a given intensity will come at an appropriate scale division. Large changes in sensitivity are best obtained by changing the size of the Geiger-Müller counter tube. The range of intensity that can be measured with a given counter will usually extend to about 10 times the lowest value for which the counter will give a satisfactory reading. Above this value the rate of pulses is so high that the "dead time" destroys the linearity of response. Therefore, the large counters useful for the measurement of low intensities fail to operate satisfactorily when the intensity rises above a certain limit. The remedy is to use a smaller counter tube for the higher intensities. The circuit described here works equally well, with minor modifications, for Geiger-Müller tube counters ranging in size from 0.5 by 1.0 cm to 5 by 30 cm, according to our experience. The calibration curve shown in figure 2 is for a counter tube 1 by 1 cm as a gamma-ray dosage indicator for an 8-hour exposure in terms of roentgens.

IV. CIRCUIT FOR RAPIDLY DECAYING SOURCES

In the adaptation of the preceding circuit to the use of Geiger-Müller counters for rapidly decaying sources and for use with activated foils in direct contact with the counter, considerable changes are necessary. The high-voltage polarity must be reversed and applied to the central electrode through a resistor, so that the outer electrode may be operated at ground potential. To allow flexibility in use and simplicity in replacement of faulty or badly contaminated counters, a 3-foot single conductor, low-capacity, shielded cable and one amphenol cable connector are used to connect the counter to the amplifier. For simplicity in connecting the counter to the cable, a short section of the high-voltage wire and counter terminal were left unshielded, with no apparent trouble from pick-up of stray electrical disturbances. The high-voltage selector, S_1, permits counters with widely different working voltages to be used with a minimum of trouble in going from one to the other. A switch and voltage divider system is provided for connecting the voltmeter circuit to the high voltage for rapid checks.

Since linear response to counting rates up to 100,000 per minute is desirable, 6AC7 tubes are substituted as amplifiers, and the time constants are kept fairly small. Referring to figure 3, it is to be noted that the screen-grid voltages on T_1 and T_2 are supplied by different methods, T_1 by a dropping resistor, and T_2 by a voltage divider. Since more than enough signal is available at the grid of T_2 to drive it to saturation, the grid is biased beyond the cutoff point, which reduces the tendency to oscillate, and therefore eliminates the necessity for decoupling resistors and capacitors in the plate circuit, and removes small pulses and ripples due to leakages and imperfect filtering in the voltage supplies.

In this circuit, the pulse arriving at rectifier T_3 is negative; therefore, to get rectification the plates are tied together and grounded and the signal is applied to the cathode. Since both d-c voltage supplies are regulated, variations caused by line-voltage fluctuations must be due to changes in heater voltage. In the previous circuit, these were balanced out by attaching the voltmeter terminals to symmetrical points with reference to the two halves of the 6H6. Here it was found that at normal heater voltage there exists a potential of about 0.8 volt between cathode and plate, which is dependent upon the heater voltage.[3] If, however, the cathode is made about 1-volt positive with respect to the plate, the line voltage is not likely to vary enough to cause this parasitic potential ever to rise beyond this value. Therefore, the voltage across the *RC* circuit is dependent only on the number of pulses arriving at the rectifier and the constants chosen for this circuit. S_2 is a four-point rotary switch which offers sensitivity ranges varying from approximately 3,000 to 100,000 pulses per minute for maximum deflection of the meter.

An added advantage in this circuit is that the resistor R_{10} between the rectifier and *RC* circuit can be as low as 0.1 megohm and still perform quite satisfactorily. In the previous circuit, however, this resistor was kept larger to minimize the effect of this parasitic potential on the linearity of the *RC* circuit. The smaller the total resistance from the cathode of the rectifier to ground, the higher the number of pulses per unit time to which the tank circuit will respond linearly. If, however, R_{10} is made too low, the net charge delivered to the tank circuit per pulse becomes too small to give adequate voltage with reasonable values of *R* in the *RC* circuit.

In instruments where portability and size are important factors, the twin triode is adequate for the bridge-type vacuum-tube voltmeter, but a little better performance is obtained if 6K6 tubes are used instead. The reversal of the polarity of the high voltage is, however, responsible for the greatest change in size and weight. A single power transformer is no longer adequate for the entire voltage supply, because the ordinary commercial power transformer does not have sufficient insulation between its windings to withstand 1,500 to 1,800 volts, which is necessary in this circuit. Since a separate transformer is necessary to heat the cathode of T_{10}, one was chosen that would give 2.5 volts, so that a 2X2 high-vacuum, high-voltage rectifier could be used. The panel of a completed instrument is shown in figure 4. This model as shown weighs slightly less than 20 pounds.

[3] J. Millman and S. Seely, Electronics, p. 204, ed. 1 (McGraw-Hill Book Co., Inc., New York, N. Y., 1941).

WASHINGTON, August 7, 1944.

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Part of Journal of Research o

HEATS OF FORMATIO
DIEN

By Edward J. Pr

Values are given for the heat of combustion, of 1,3-butadiene at 25° C.

I. Introduction
II. Unit of energy, molecular
III. 1,3-Butadiene
IV. Styrene
V. Tabular summary
VI. References

I. I

The previously publishe of formation of 1,3-butadi combination of values of t to *n*-butane [2], the heat o formation of water from its carbon dioxide from its el for the heat of formation o heat capacities of *n*-butane come available, a revised butadiene can be calculate heat of combustion of 1,3-b

The existing values for t styrene are based on old [17, 18, 19, 20, 21, 22]. Nev obtained in this laboratory of formation from the elem

II. UNIT OF ENERG

The unit of energy upon are based is the internation

This investigation was performed at th Laboratory and the American Petroleum Data on the Properties of Hydrocarbons. Figures in brackets indicate the literat

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U. S. Department of Commerce — National Bureau of Standards

RESEARCH PAPER RP1666

Part of Journal of Research of the National Bureau of Standards, Volume 35, August 1945

THIN-WALLED ALUMINUM BETA-RAY TUBE COUNTERS

By Burrell W. Brown and L. F. Curtiss

ABSTRACT

A description is given of aluminum-tube Geiger-Müller counters having a wall thickness of 0.004 inch and constructed from commercially available tooth-paste tubes. These tubes as furnished are in the hard temper and have uniform wall thickness, which enable them to stand complete evacuation without a tendency to collapse. By copperplating the aluminum it is possible to soft-solder fittings to the tube to construct a counter that can be permanently sealed after filling and that will maintain its characteristics over a long period. The procedure reduces the cost of making this type of counter, as the aluminum tubes are inexpensive, and very simple operations are required in the construction of the counters.

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II.	Thin-walled aluminum tubes	147
III.	Copperplating the aluminum tube	148
IV.	Construction of the Geiger-Müller counter	149

I. INTRODUCTION

An economical method of making thin-walled aluminum Geiger-Müller counter tubes for the measurement of beta rays would greatly increase the usefulness of this type of instrument in the field of radioactivity. Present methods require, the boring of metal tubes or rods [1] to a thin wall. This is a delicate and expensive operation, and the thinnest walls obtainable are approximately 0.007 inch. Thin-walled counters have also been made by drawing glass tubing to a thin-walled section and silvering the inside.[2] This procedure does not give a very uniform wall, which is usually of a thickness greater than that corresponding to 0.007-inch aluminum. Other methods require the use of wax seals, which do not yield tubes of very long life as the organic vapors commonly used in filling counters attack most waxes.

II. THIN-WALLED ALUMINUM TUBES

It has recently been noted that thin-walled aluminum tubes quite suitable for the construction of counters are commercially available. A typical tube is ⅝ inch in diameter and 4½ inches long, with walls 0.0044 ± 0.0004 inch in thickness. The walls are uniform throughout

[1] J. R. Dunning and S. M. Skinner, Rev. Sci. Instr. 6, 243 (1935); J. Halpern and O. C. Simpson, 8, 172 (1937).
[2] A. H. Barnes, Rev. Sci. Instr. 7, 107 (1936); J. C. Wang, J. F. Marvin, and K. W. Stenstrom 13, 81 (1942).

the length and circumference within the limits indicated. These tubes are made in quantity as containers for such materials as tooth-paste and are furnished with one end fitted with the conventional screw cap and the opposite end open to the full diameter of the tube. Made by mass-production methods these tubes are inexpensive and of very uniform dimensions, and therefore are suitable as a component of a beta-ray counter. They are in the hard temper, which enables them to withstand complete evacuation with no tendency to collapse.

III. COPPERPLATING THE ALUMINUM TUBE

It is of advantage to construct counters that can be filled and sealed permanently so that they will maintain their characteristics over considerable periods of time. This requires the elimination of wax seals, gaskets, and similar arrangements. To accomplish this with the aluminum-tube counters, it has been found desirable to plate the aluminum with copper to permit the use of soft solder in joining the parts. There are several methods by which an adherent plating of copper can be applied to aluminum. For the benefit of those who may desire to construct such counters, the method of plating found most convenient is described.

The first step is to clean the aluminum surfaces to be plated in a strong solution of potassium hydroxide, immersing the aluminum until a smooth film of water will spread over it uniformly, indicating that the aluminum surface is clean. The next step is to anodize the aluminum surface. After rinsing all the potassium hydroxide solution from the aluminum, it is used as an electrode in a solution of 10- to 15-percent oxalic acid to produce an anodic film on the surface. It is convenient to anodize two pieces together by using them as electrodes connected to the alternating-current supply through a variable-voltage transformer. Initially, the voltage applied should be of the order of 1 or 2 volts, and this may be increased to around 50 volts as the anodic film develops. Care should be taken to hold the voltage low enough at all times to avoid heating of the solution by the current. After 15 to 20 minutes the aluminum is removed, rinsed in cold water, and etched for a few seconds in a 1-percent hydrofluoric acid solution until a slight evolution of gas is apparent. It is then immediately rinsed in cold water, and the surface is ready for plating. The usual copper sulfate solution, to which a small amount of sulfuric acid has been added, is used for plating. The plating of a layer of copper a few thousandths of an inch in thickness requires about 20 minutes. In constructing the counters, both ends of the tubes are plated with copper. If copper is deposited over a larger area than is desired, the excess may be removed at any time by etching with strong nitric acid, which has little effect on the aluminum.

The etching of the anodic coating with hydrofluoric acid may be eliminated if care is taken to develop a thin coating in the anodizing process. The proper thickness is obtained by interrupting the anodizing process when the potential reaches about 2 volts. Some difficulty may be encountered in determining the proper conditions to secure an adherent coating of copper by use of this alternative method.

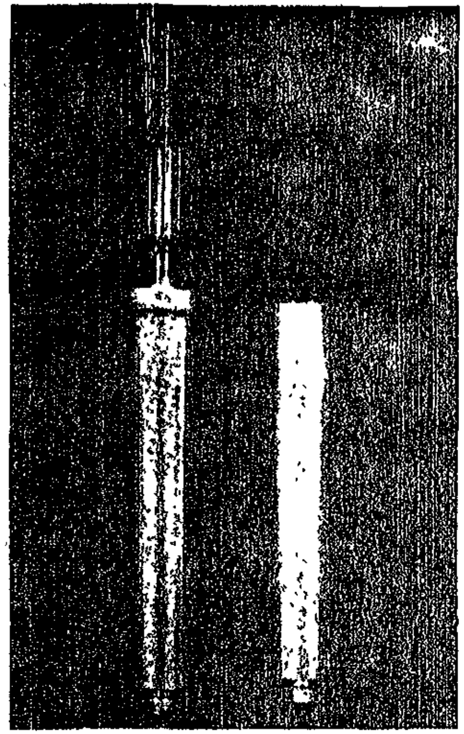

FIGURE 3. -*Completed counter.*

IV. CONSTRUCTION OF THE GEIGER-MÜLLER COUNTER

The assembly of the counter is shown in cross section in figure 1. The circular end of the tooth-paste tube, *T*, is closed by the copper bushing, *B*, which is soft soldered to the plated aluminum tube, as indicated. The bushing is fitted with a ¼-inch Kovar tube, *K*, silver-soldered in an axial hole, as shown. A short glass tube sealed to *K* provides a support for one end of the central wire, *W*, and also carries a side tube for evacuating, filling, and sealing the counter. The glass tube is continued inside of *K* to form a sleeve around the central wire. The opposite end of the aluminum tube is closed by a copper plug, *P*, soldered into the small tubular opening of the tube. The plug is drilled to take a small piece of Kovar wire, which carries a glass bead, *G*, to serve as a support for the central wire at this end. The plug and wire are soft soldered in one operation to the aluminum tube, previously copperplated at this point.

The order of assembly found convenient is first to silver solder tube *K*, into copper bushing, *B*. The glass tubing is then sealed into *K* and the bushing, *B*, soft soldered into tube, *T*. The central wire system is then made up and lowered into *T* to protrude through the screw-cap end. Copper plug, *P*, is soft soldered to the short Kovar wire and then into *T*. The Kovar wire, *R*, is then pulled into position at the opposite

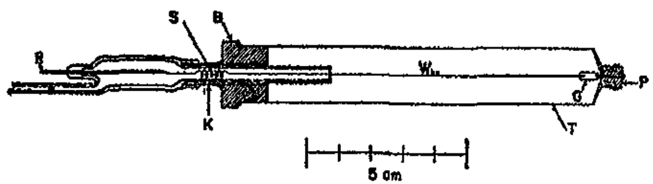

FIGURE 1.—*Cross section of assembly of counter.*

end and sealed into the glass. The dimensions are such that there is a moderate tension on the spring, *S*. If the dimensions are carefully chosen this spring may be eliminated.

The performance of the finished counter depends, of course, on the type of filling used. In the counter described here, the usual alcohol-argon mixture has been found to yield plateaus and thresholds similar to other types of Geiger-Müller counters containing this mixture. A slope of 0.1 percent per volt is readily obtained. A curve showing the variation of counting rate with voltage applied to the counter is shown in figure 2. This curve is maintained for several months, which is as long as the counters were under observation. Experience indicates that a counter will leak occasionally as a result of imperfect soldering. This can be quickly repaired. In a few cases it was also found that the aluminum tooth-paste tubes have a small leak, probably due to pin holes. Perhaps 5 percent of the tubes may have this defect, which can be detected by preliminary evacuation.

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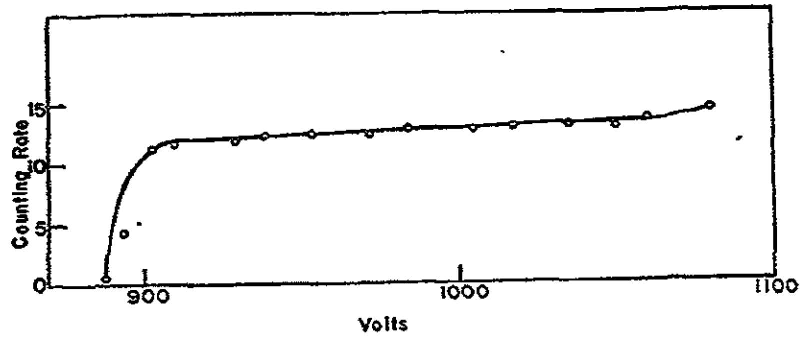

Figure 2.—*Variation of counting rate with voltage applied to counter.*

A completed counter, ready for filling, and an empty tube are shown in figure 3. Aluminum tubes of other diameters but of approximately the same wall thickness and that do not collapse on evacuation are also available commercially.

Washington, May 4, 1945.

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National Bureau of Standards

Research Paper RP1731
Volume 37, August 1946

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An Arrangement with Small Solid Angle for Measurement of Beta Rays

By Leon F. Curtiss and Burrell W. Brown

An arrangement using a Geiger-Müller counter with small aperture with a radioactive source at some distance from it is described for counting beta particles. Sources emitting only beta rays with maximum energies above 1 million electron volts of the order of 1 millicurie can be measured in terms of the disintegration rate from the observed counting rate and the solid angle as calculated from the dimensions of the apparatus. An independent check of the arrangement shows that this can be done reliably. A suggestion for discarding the use of the curie and substituting a unit consisting of 10^6 disintegrations per second to be called the "rutherford" is made. The curie is properly applicable only to members of the radium family.

I. Introduction

The development of improved methods for the production of radioisotopes, resulting in an increase in the use of such radioactive materials, has led to a demand for better methods of measurement. In the simple case where a radioelement emits only beta particles of fairly high energy, as in the case of P^{32}, it should be comparatively easy to measure the strength of radioactive sources in terms of disintegrations per second, even for fairly strong sources. This has not yet been accomplished, however. Disagreements of the order of 300 percent have come to the attention of the authors. The need for reliable methods of measuring the strength of sources of P^{32} is accentuated by its newly developed use in the treatment of leukemia. It is of considerable importance that the amounts of P^{32} as measured by various laboratories should be in reasonable agreement. Otherwise, clinical results obtained in various parts of the country from the use of this element cannot be compared.

The writers have undertaken to develop an arrangement, comprising a Geiger-Müller counter and source holder, with a sufficiently low solid angle that sources of the order of 1 millicurie can be counted in it directly. The number of disintegrations per second will then be obtained from the observed counting rate and the solid angle determined from the dimensions of the arrangement.

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II. Geometrical Arrangement

Figure 1 is a diagram of the counter, chamber, and source holder built to test the effectiveness of this method of measuring beta-ray sources. A brass tube approximately 60 cm long and 4-cm internal diameter constitutes the chamber. In this a number of baffles, *B*, are mounted with a movable shutter, *Sh*, of 3-mm brass at the end where the source, *S*, is mounted. This shutter permits a measurement of background with a source in place. The opposite end of the chamber is closed by a steel plate, *P*, 6 mm thick with an aperture, *A*, 4 mm in diameter in the center. A counter, *C*, is mounted concentric with *A*, which is covered by a mica window of approximately 2 mg/cm². The chamber can be evacuated during observations. The construction of the source holder is shown in figure 2. It is made of Plexiglas and designed to reduce back-scattering from various parts.

The most important spurious effect to be anticipated in this arrangement is small-angle scattering from the walls of the tube. The very small solid angle used makes this a serious difficulty. Consequently, a series of studies was made of the effect of baffles of various materials, at different locations in the tube, on the counting rate. These studies revealed that Plexiglas and soft-wax baffles were equally effective in producing a definite minimum counting rate when the source was in full view of the aperture.

Typical results are shown in table 1 for equally spaced baffles, consisting of disks ¼ in. thick

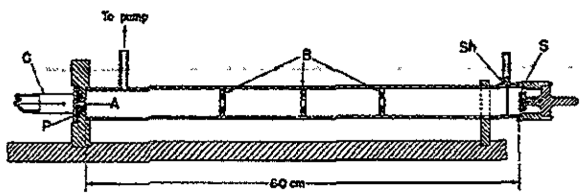

FIGURE 1.—*Arrangement of counter, vacuum chamber, and source holder.*

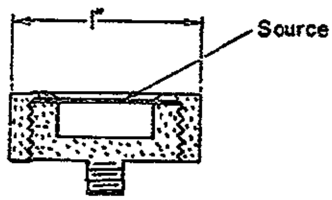

FIGURE 2.—*Beta-ray-source holder*

closely fitting the internal diameter of t with a central hole ½ in. in diamete diameter of the source was 1 cm.

The optimum diameter of the circular in the baffles was found to be slightly than the diameter of the source. Small at this approximate diameter had no effec counting rate.

TABLE 1.—*Relative scattering for different arra of baffles*

Material	Number of baffles	Relati counti rate
	0	1.27
Brass	3	0.56
Plexiglas	3	.50
Do	4	.50
Do	12	.56
Wax	3	.50

The effect of internal scattering along t was further tested by changing the so aperture distance from 60 to 40 cm by m the source on a rod extending 20 cm into t The counting rate observed under these co agreed within less than 1-percent wit calculated from the ratio of the calculat angles and the counting rate observed at

From the actual dimensions of the a diameter =4.06 ±0.01 mm, and so aperture distance equals 60.0 ±0.2 cm, t angle divided by 4π is computed as 2.8 Multiplying the observed counting rate reciprocal of this number, 3.49×10^{5}, gi number of disintegrations per second. desired to express this value in millicur observed count is multiplied by 9.4 assuming the curie as 3.7×10^{10} disinte per second. This practice of express activities in terms of curies is to be conden will be explained later.

There are at least three disturbing common to all Geiger-counter measurem beta rays, which must be considered in con with the present arrangement. These ar scattering from the source and support, abs in the mica window and in some cas absorption in the source. In the present c back-scattering from the support for the was reduced to a minimum by the selec doc. A 17 p. 3

Plexiglas with a considerable cavity behind the source to reduce this effect. The sources were deposited on aluminum 0.00035 in. thick. However, the material of the source itself would cause considerable back-scattering, as the phosphorus used did not have a high specific activity, and there also would be some self-absorption. These effects tend to counteract each other.

III. Independent Check on Solid Angle

A number of P^{32} sources were measured in the arrangement as described. The values obtained were in general agreement with those expected, but it became obvious that some independent check was required to establish the reliability of the measurements. For this purpose a thin mica-window counter of the bell type was constructed and arranged so that a source could be mounted very close to the window in an accurately reproducible location. This was achieved by mounting the counter with the mica window up and laying the sources, properly centered, directly on the counter. The curvature of the mica window provided a small but definite separation between it and the source. This arrangement is represented in figure 3, where S is the source and M the mica window.

To determine the solid angle for this position of the source a sample of RaD was prepared from lead extracted from pitchblende to be used as a standard. The radium content of this ore was carefully measured, and the total amount of lead was determined quantitatively. From the above data and the known weight of lead in the standard, the number of beta rays per second from the RaE in equilibrium with the RaD could be calculated.

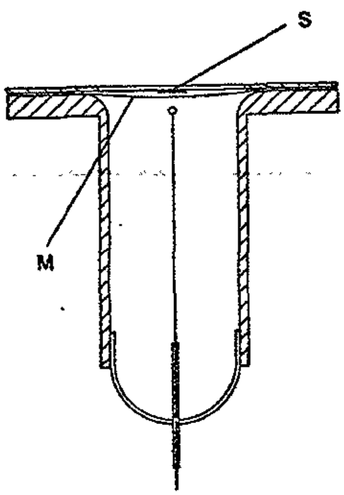

FIGURE 3.—*Mica-window counter.*

The ratio of the observed number of counts to this calculated value gives the effective aperture of the counter. With this information available, an aliquot was taken from one of the P^{32} solutions, of such amount to give a convenient counting rate in the inverted mica-window counter. The counting rate multiplied by the above ratio gives the number of disintegrations per second in the aliquot of P^{32}. Multiplying again by the aliquot ratio, the number of disintegrations is obtained in the original P^{32} sample, which had previously been measured in the chamber with small solid angle. In making these measurements in comparison with the RaD+E standard, care was taken to deposit the P^{32} on the same backing material as was used for the standard and over the same area. This reduces the back-scattering correction to a small value, dependent only on the difference in energies of the RaE and P^{32} beta rays. The mica window had a thickness $\sim$ 6 mg/cm^2, so that the absorption corrections would also be nearly the same.

When comparing the measurements in the arrangement with large solid angle with those obtained in the apparatus with small solid angle, it is to be noted that whereas the effect of back-scattering in the former has been reduced, this is not true for the small-angle arrangement as there were several milligrams of phosphorus in the sources of approximately 0.5-millicurie strength. Therefore, we would expect the value obtained in this case to be somewhat higher than that obtained from comparison with the RaD+E standard. On the other hand, for the large solid angle arrangement there is almost no self-absorption of beta rays in the material of the source due to the smallness of the sample, whereas in the small solid-angle apparatus a source of approximately 0.5 mc weighs about 30 mg and extends over a little less than a square centimeter. The self-absorption will be considerable under these conditions. A measurement gave 0.489 mc for 30 mg in the high, large solid-angle arrangement and 0.488 mc for the low solid-angle arrangement. Under the conditions of these measurements the

A 17 p. 4

results can only be explained if the back-scattering effect was approximately offset by self-absorption within the source. The agreement might be regarded as fortuitous. Therefore, the comparison was repeated from the beginning, using freshly prepared sources from the same original solution of P^{32} in both pieces of apparatus. The measurements gave 0.504 mc in the large solid-angle counter and 0.502 mc in the low solid-angle arrangement. This makes it quite certain that the low solid-angle chamber gives a reliable measurement of beta rays from P^{32} or any source emitting only beta rays of approximately the same energy. Furthermore, this counting arrangement is independent of any standard and gives the disintegration rate simply by multiplying the observed counting rate by the solid angle computed from the dimensions of the apparatus.

IV. Use of the Curie

It has become the practice to express the strength of all radioactive sources in terms of curies. Actually, the curie can be applied logically only to members of the radium family. This arises from the fact that the curie was originally defined as "That quantity of radon in equilibrium with 1 of radium." Therefore, only members of the radium family in equilibrium with 1 g of radium can have this disintegration rate. A further disadvantage in the use of this unit is that it is uncertain to at least 4 percent and values are in current use which fall well outside these limits.

The solution of this difficulty is remarkably simple. The intensity of radioactive sources is measured actually in terms of disintegrations per second. Therefore, all that is required is to designate some convenient rate and give it a name. We suggest that a convenient rate is 10^6 disintegrations per second, and that the unit be called a "rutherford," abbreviated as "rd." The microrutherford then is the amount undergoing 1 disintegration per second and a kilo rutherford, 10^9 disintegrations per second. In the future it is anticipated that even those nucleii having fairly complex disintegration schemes will be measurable in terms of disintegrations per second, and many can already be treated in this way. Thus all confusion that has arisen from the false application of the curie can be eliminated.

This subject has been discussed by the National Research Council Committee on Radioactivity, which, in turn, has suggested that the National Bureau of Standards recommend the use of the "rutherford" as a general unit for the measurement of radioactive sources. This recommendation was published in Science **103,** 712 (1946), and will appear shortly in other journals.

WASHINGTON, May 23, 1946.

(doc A 18)

Right—
Center—;
About to release balloons carrying equipment for the Study of Cosmic Ray intensity in the Stratosphere.

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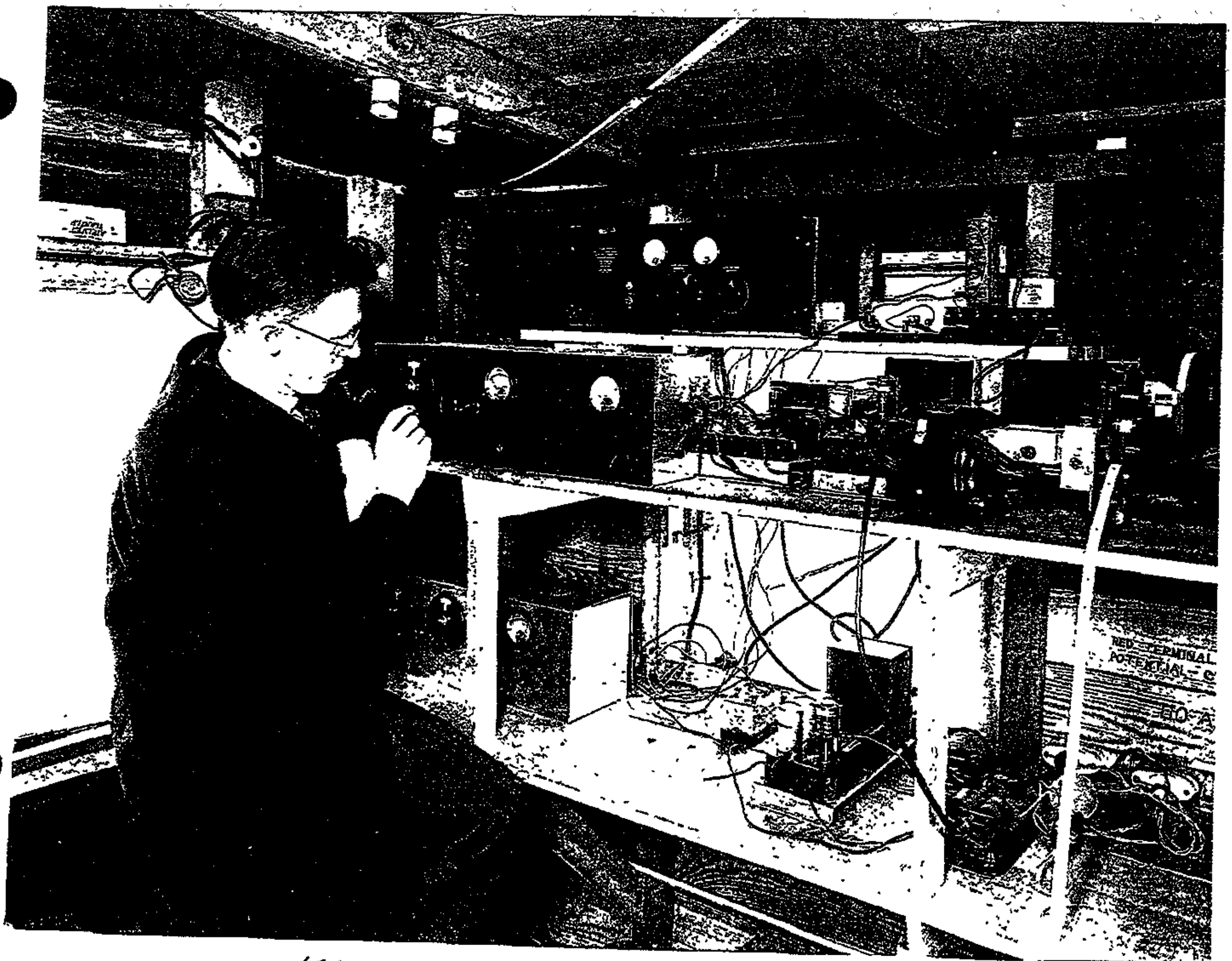
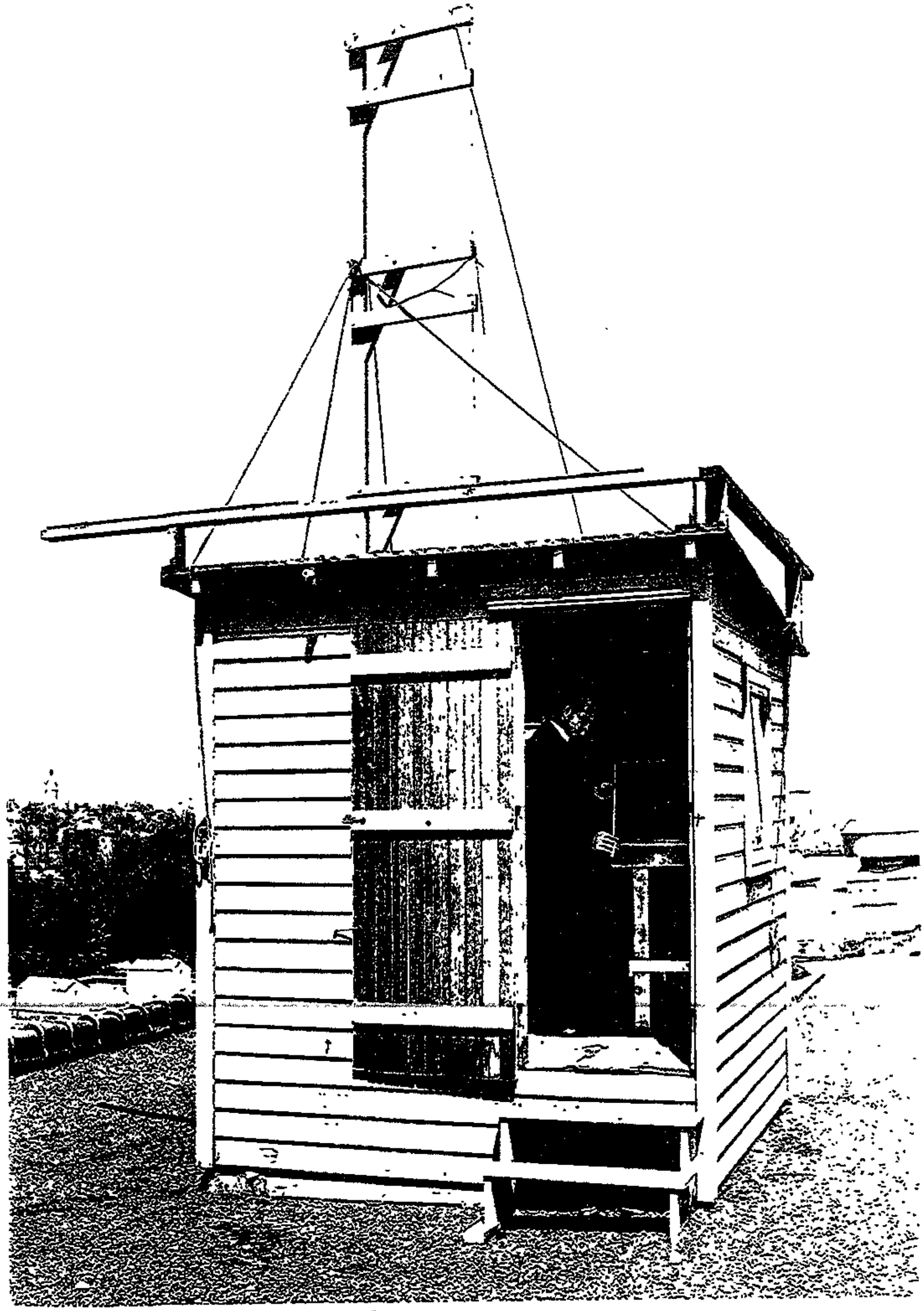


May 27, 1936. Equipment on the upper shelf is the receiver and automatic recorder.
Shown at the controls.

↑ This is my writing copied from the back of this picture which was taken by him.

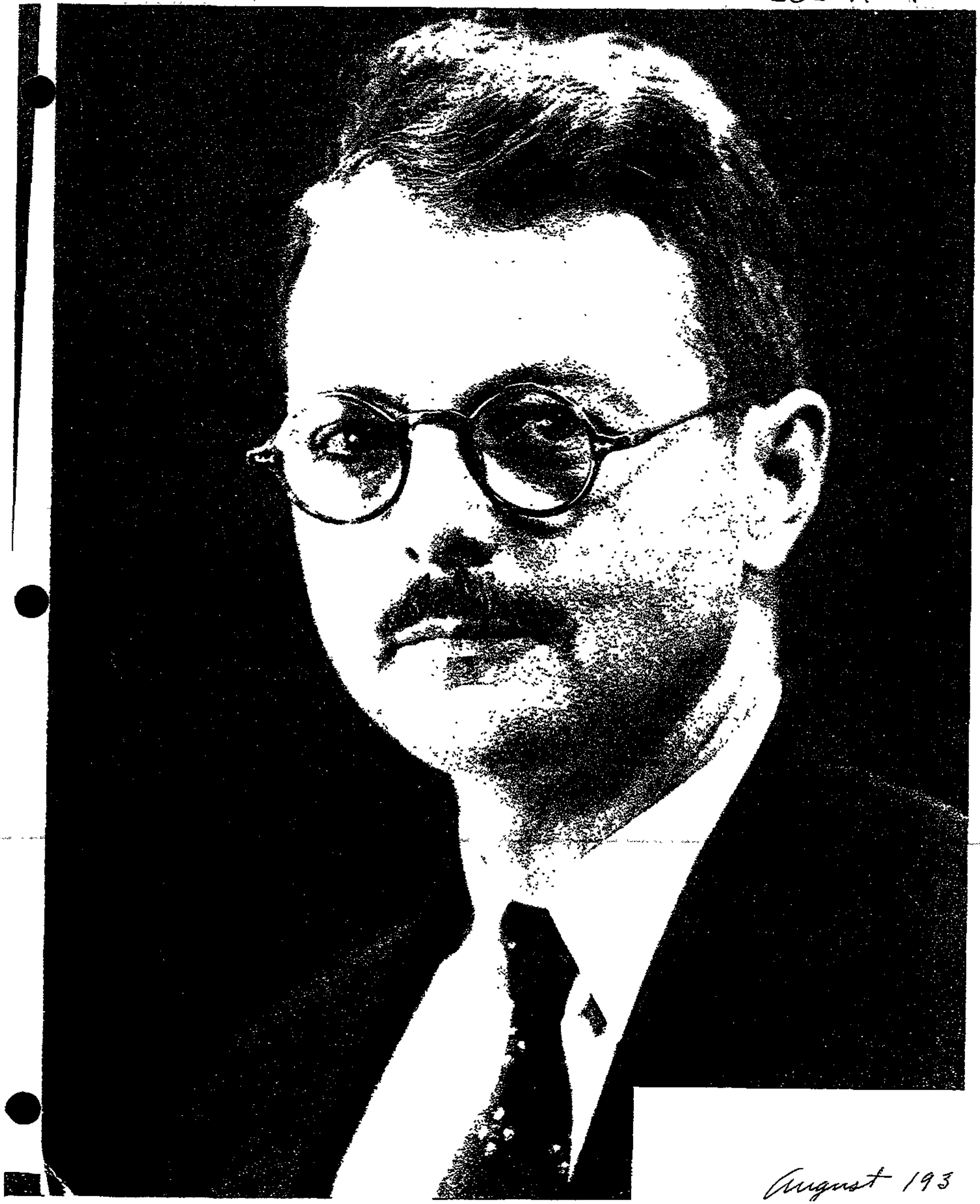
doc A 20



May 27 1936,
The penthouse on the roof of the West bldg. at the National Bureau of Standards.
inspecting the record.

↑ . writing, copied from the back of

doc-A21



August 193

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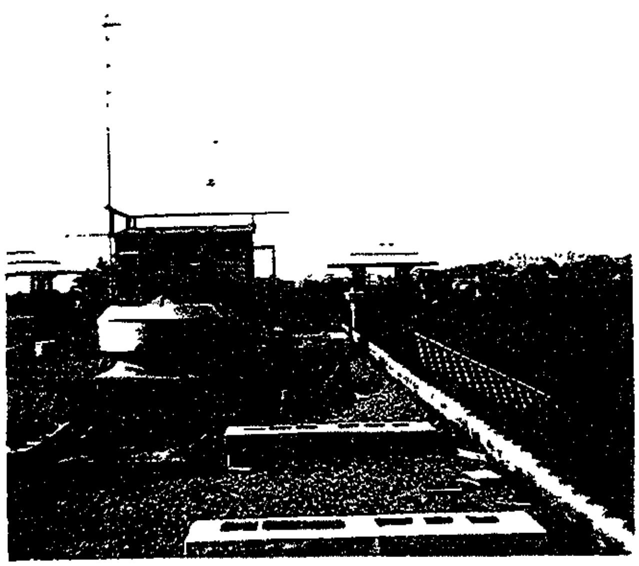
(Doc M 45)



Roof of NBS. Experiment being conducted in the distance - see balloon at top of picture.

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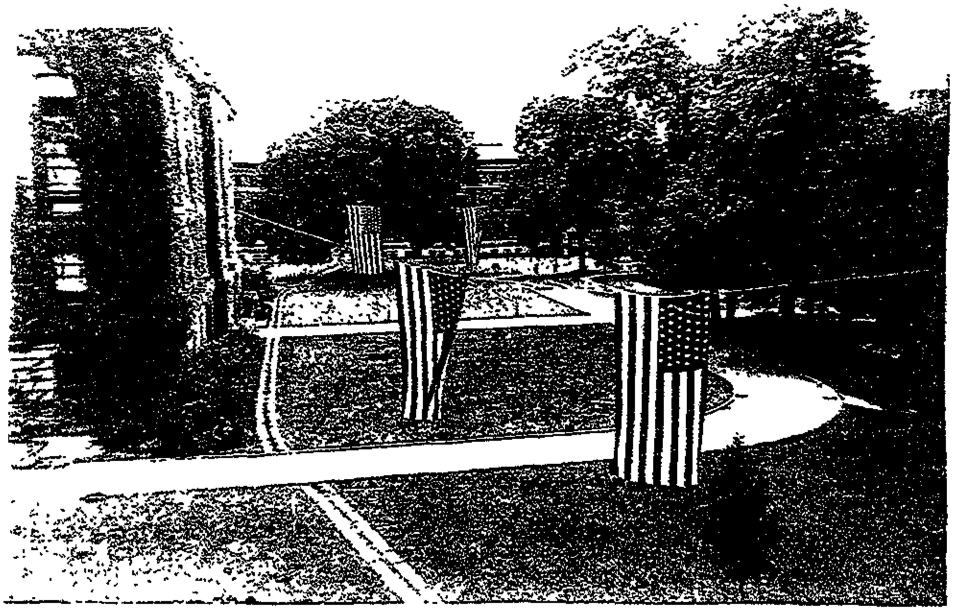

Photo taken by
National Bureau of Standards
Van Ness Street
Washington, D.C.

as a young man.
Equipment he designed* for the study of cosmic ray intensity in the stratosphere. (*info from Dr. Mendell.)

physics.nyu.edu

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